



21 JANUARY 2022

**Report of the Inquiry
Committee for the accident
at Stars Engrg Pte Ltd on
24 February 2021
(PART II – ANNEXES)**

TABLE OF CONTENTS

Part II – Annexes

ANNEX A – STOP WORK ORDER	A-1
ANNEX B – BIOGRAPHIES OF IC MEMBERS	B-1
ANNEX C – LETTERS OF APPOINTMENT	C-1
ANNEX D – TERMS OF REFERENCE OF THE IC	D-1
ANNEX E – OPENING STATEMENT	E-1
ANNEX F – LIST OF WITNESSES	F-1
ANNEX G – LIST OF EXHIBITS	G-1
ANNEX H – LIST OF WITNESS STATEMENTS AND SUBMISSIONS	H-1
ANNEX I – EXPERT REPORTS	I-1
ANNEX J – WRITTEN REPRESENTATIONS	J-1
ANNEX K – CLOSING SUBMISSIONS	K-1
ANNEX L – EXTRACTS FROM THE WORKPLACE SAFETY AND HEALTH ACT	L-1
ANNEX M – EXTRACTS FROM THE WORKPLACE SAFETY AND HEALTH (RISK MANAGEMENT) REGULATIONS	M-1
ANNEX N - EXTRACTS FROM THE WORKPLACE SAFETY AND HEALTH (GENERAL PROVISIONS) REGULATIONS.....	N-1
ANNEX O – EXTRACTS OF COMBUSTIBLE DUST-RELATED LEGISLATION	O-1

ANNEX J – WRITTEN REPRESENTATIONS



RECOMMENDATIONS REPORT

FIRE AND EXPLOSION AT STARS ENGRG PTE LTD (32E, TUAS AVENUE 11)

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A handwritten signature in black ink, appearing to read 'Shaik Mohamed Salim'.

Prepared for



3 November 2021

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Contents

List of Tables	3
Abbreviations	4
Executive Summary	5
1 Background and Introduction.....	7
2 Methodology - Gap Analysis.....	8
3 FMEA Results and Recommendations.....	9
3.1 Items (1) and (2) – HTF fill and Heating of HTF	9
3.2 Item (3) – Heating jacket integrity.....	12
3.3 Item (4) – Release and formation of liquid aerosols	14
3.4 Item (5) – Combustible dust.....	16
4 Conclusion	18
References.....	20
Appendices	21

List of Tables

Table 1: Summary of recommendations on legislative requirements.....	18
Table 2: Summary of recommendations related to standards, guidance material and training development	19

Abbreviations

ACOP: approved code of practice under s 40B of the WSH Act

CSC: Chemical Standards Committee

FMEA: Failure Mode and Effect Analysis

HTF: heat transfer fluid

ISO: International Organization for Standardization

MOM: Ministry of Manpower

NFPA: National Fire Protection Association

OSHA: Occupational Safety and Health Administration of the United States of America

RMCP: Code of Practice on Workplace Safety and Health Risk Management (issued by the WSH Council)

SCDF: Singapore Civil Defence Force

SME: small and medium sized enterprises.

SMF: Singapore Manufacturing Federation

SOP: standard operating procedures

SS: Singapore Standard

SWP: safe work procedures

WSH: Workplace Safety and Health

Executive Summary

2

The accident at Stars Engrg involved a primary deflagration caused by the release and ignition of aerosolised combustible liquid (i.e. HTF) from an over pressurised heating jacket followed by secondary flash fires from combustible dust. An FMEA was conducted to systematically analyse and identify gaps within the current legislative requirements and supporting standards. The results from this FMEA has led to a total of five recommendations on regulatory requirements and five recommendations on standards, guidance material and training.

10

In order to prevent accidents involving combustible liquid aerosols from overheated and over pressurised heating systems, recommendations are made for the WSH Act to ensure that closed, heated systems that are not intended for pressurised operations are explicitly defined/covered and properly installed/commissioned under the WSH Act and its subsidiary regulations. Similarly, in the WSH (General Provisions) Regulations, recommendations on control measures and maintenance are made for such heated systems along with explicit definitions for “combustible liquid aerosols” and “flammable gases and vapours arising from material decomposition”.

18

To support these regulatory requirements, recommendations are also made to review and enhance SS 537¹ and the RMCP (an ACOP) in terms of their controls for heated equipment/systems, provision of safety information and risk assessments of such equipment/systems. It is also recommended that the Chemical Standards Committee (CSC)² look into the feasibility of developing standards to address hazards associated with combustible liquid aerosols and thermal decomposition of materials. At the same time, it is also recommended that the CSC look into the research needed to close the knowledge gaps for the development of such standards. Recommendations are also made to develop guidance

24

¹ SS 537 (2008), Code of practice for the safe use of machinery – Part 1: General requirements (published by Enterprise Singapore).

² Established under the Singapore Standards Council appointed by Enterprise Singapore.

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material and training for SMEs to help increase awareness of material thermal decomposition
2 hazards, liquid aerosol explosions and equipment commissioning best practices.

In terms of combustible dust hazards, it is recommended that the WSH Act and the WSH (General
4 Provisions) Regulations be enhanced via the gazetting of SS 667³ as an ACOP. It is also recommended
that the RMCP references and integrates SS 667's Dust Hazard Analysis (DHA) as part of the overall
6 risk assessment regime.

³ SS 667 (2020): Code of practice on handling, storage and processing of combustible dust (published by Enterprise Singapore).

1 Background and Introduction

2

The root-cause of the incident on 24 February 2021 at Stars Engrg was likely to be the low amounts
4 of heat transfer fluid used in the mixer. This then led the heat transfer fluid to be excessively heated
resulting in a pressure build-up in the mixer's heating jacket. This subsequently led to the rupturing
6 of the heating jacket thus releasing hot, pressurised heat transfer fluid into the environment. This
pressurised release likely atomised the heat transfer fluid to form a liquid aerosol that was then
8 probably ignited by a hot surface. The ignited aerosol cloud resulted in the primary deflagration with
significant overpressures.

10

This primary deflagration event was followed by up to three secondary deflagrations in the form of
12 flash fires. These flash fires were likely the result of potato starch within the Stars Engrg factory unit
that were initially agitated and suspended by the overpressure from the primary deflagration to form
14 a combustible dust cloud.

16

The causes and evidence related to this accident were documented in my technical accident report
dated 13 Sep 2021. The sequence of events involved in the accident is illustrated in the accident block
18 flow diagram at page 60 of that report. The accident block flow diagram is reproduced at **Appendix**
A to this report, with additional labelling to draw attention to the five discrete items representing
20 the key components in the accident block flow diagram (see page 8 below).

22

In order to prevent such an event from occurring again, suitable preventive measures should be put
in place. In this report, a systematic and structured review of the key factors involved in the accident
24 are analysed in order to derive specific measures that could be implemented. The methodology used
for this analysis is explained in the following section.

2 Methodology - Gap Analysis

2

Failure Mode and Effect Analysis (FMEA) was the methodology employed to review the various
4 factors involved in the accident. This methodology is designed to systematically analyse components
and sub-systems to identify potential failure modes in a system, their causes and relevant
6 consequences.

8 In this FMEA analysis, the system being analysed was the sequence of events involved in the accident.
As shown in **Appendix A**, five discrete items were identified to represent key components in the
10 accident block flow diagram namely:

- (1) HTF fill in heating jacket
- 12 (2) Heating of HTF
- (3) Heating jacket integrity
- 14 (4) Release and formation of liquid aerosols
- (5) Combustible dust

16

The five key components were then examined with particular emphasis being placed on existing
18 measures available and recommendations for improvements. The detailed FMEA analysis done is
shown in **Appendix B**.

20

It should be highlighted that this FMEA was conducted to ascertain gaps and potential improvements
22 in the safety systems, regulatory framework and standards/guidance at the national level. This FMEA
was not done to identify specific component failures of the mixer machine involved in the accident.

3 FMEA Results and Recommendations

2
The results from the FMEA generated a number of recommendations to address gaps.

4 3.1 Items (1) and (2) – HTF fill and Heating of HTF

6 The possible causes of failures under these two items can be summarised as follows:

- 8 a. Equipment ergonomics – distinguishing touch points⁴ and anticipating misuse.
- 10 b. Equipment safety information and hazard communication – language clarity and specificity for global users.
- 12 c. Improper risk assessment – assessments of tasks that are more related to construction site activities.
- 14 d. Improper equipment commissioning – lack of awareness of best practices in equipment commissioning.
- 16 e. Poor/missing SOP – limited engineering and professional knowledge/experience with process-type equipment (i.e. the mixer machine).

18 In terms of factors (a) and (b) that involve equipment safety and provision of information, Section 16 of the WSH Act specifies the general duties of manufacturers and suppliers of machinery or equipment used at work to ensure that such machinery or equipment is:

- 20 i. provided with safe use information;
- 22 ii. safe and without risk to health when properly used; and
- iii. adequately examined and tested.

24 The types of equipment currently covered under this section is listed under the Fifth Schedule which includes equipment intended for operation under pressure and equipment intended to contain
26 corrosive, toxic or flammable substances. Therefore, there seems to be a gap for equipment that are not primarily intended to be operated under pressure or equipment that only contains combustible
28 (but not corrosive, toxic or flammable) materials. In particular, heated equipment or equipment with energy inputs into closed systems that could result in overheating or overpressure would need to be

⁴ Controls and other areas on machines users might touch

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covered in Section 16 of the WSH Act. Whilst it is acknowledged that the mixer machine involved in
2 the accident was purchased online from an overseas manufacturer / supplier and that the reach of
the WSH Act is limited in this regard, it is important to ensure that the gap in the WSH Act is addressed
4 as regards local manufacturers/suppliers to prevent future accidents.

Other than legislation via the WSH Act, equipment safety is currently addressed in SS 537 Part 1⁵,
6 which is an ACOP applicable to all workplaces defined within the scope of the standard. This standard
mainly covers mechanical safety issues for example entanglement, cutting and impact hazards.
8 Adoption of SS 537 Part 1 is mandatory. Although SS 537 does not cover overheating, overpressure
and explosion hazards, it does provide general guidance related to selection of safety measures, risk
10 reduction, safeguards and safety devices. It might therefore be appropriate to review this standard
to cover heated equipment (e.g. the mixer machine) with reference to ISO 12100 and in particular,
12 attention should be given to guidance on “Information for Use”⁶. This should raise the equipment
safety awareness of equipment manufacturers/suppliers and end-users. It should also address the
14 quality of safety information provided by the manufacturer and suppliers of equipment.

16 For factor (c), requirements on risk assessment are stipulated under the WSH (Risk Management)
Regulations with further details provided by the RMCP. The guidance provided by the RMCP is
18 designed to provide hazard identification and risk assessment for a wide range of industries and work
environments ranging from construction, shipyards and general manufacturing. Although the general
20 principles provided in the RMCP can be made applicable to almost all risk assessments, the
methodology described in the RMCP is more activity or task-centric. This means that process-type
22 interactions and their related hazards could be inadvertently missed out by the average risk assessor.
It might therefore be beneficial to review the RMCP and include guidance and examples to enable
24 better identification of process related hazards (e.g. overpressure, decompositions).

26 The fourth factor (d) identified under Items (1) and (2) was related to equipment commissioning
practices. Although commissioning is not explicitly mentioned, its requirements are implied under

⁵ SS 537 (2008), Code of practice for the safe use of machinery – Part 1: General requirements.

⁶ ISO 12100-1 (2010), Clause 6.4 – Information for use

2 Section 17 of the WSH Act which covers the duties of persons who install or modify machinery or
equipment. It is therefore recommended that this section be enhanced with the inclusion of key
commissioning components such as equipment/process design and information review,
4 determination of system boundary limits, inspection and acceptance testing, safe start-up and
documentation.

6

8 For many SMEs⁷, there is usually a lack of experience and expertise in commissioning equipment prior
to operational start-up. It would therefore be helpful if a guidance document is developed with the
relevant industry association (e.g. SMF) on commissioning best practices for SMEs as a resource and
10 as a basis of training programme. This would be similar to courses aimed at other specific aspects of
safety management such as risk assessments and safe work procedures. It should be noted that there
12 are courses currently conducted under the Skills Framework (SFw)⁸ for commissioning activities.

14 Finally, for factor (e), the development and implementation of safe work procedures have been an
established practice in many workplaces and is stipulated in broad terms under Section 12 of the
16 WSH Act and more specifically under the WSH (Risk Management) Regulations⁹ with detailed
guidance provided by the RMCP and SS ISO 45001. However, the issue lies with the types and quality
18 of safe work procedures developed and implemented since they are heavily influenced by the risk
assessment conducted and the experience or background of the people developing such procedures.
20 In this accident, although safe work procedures were available, they addressed activities that are
more closely linked to off-site work which the company had more experience dealing with such as
22 working from heights and manual handling. Overall, for safe work procedures, the regulatory
requirements and the standards available are adequate and the shortcomings identified would have
24 been addressed by the recommended changes in risk assessment mentioned previously under factor
(c).

⁷ SME: small and medium sized enterprises.

⁸ Developed by SkillsFuture Singapore (SSG), Workforce Singapore (WSG), and the Singapore Economic Development Board (EDB) for Engineering Services: <https://www.skillsfuture.gov.sg/skills-framework/engineeringservices>.

⁹ Regulation 4 – Elimination and control of risk.

3.2 Item (3) – Heating jacket integrity

2 The possible causes that could result in overpressure, vessel rupture and release of HTF are as follows¹⁰:

- 4 a. Closed system – not for pressurised service with no safeguards e.g. venting, pressure monitoring
- 6 b. Overheating of HTF – electrical heating of combustible liquid
- c. Decomposition of HTF – decomposition of combustible liquid at high temperatures
- 8 d. Lack of technical knowledge – thermal runaways, decomposition and liquid aerosol explosion

10

Referring to factor (a), vessels that are not intended for pressurised operations do not have any specific requirements under the WSH (General Provisions) Regulations that currently covers pressure vessels and includes additional obligations as regards pressure vessels containing hazardous substances (i.e. Regulation 33). However, it should be noted that closed systems (even if not intended for pressurised operations) could also experience overpressures when subjected to operational deviations. There should therefore be provisions under the WSH (General Provisions) Regulations for measures to ensure that overpressures could be prevented or controlled in such closed systems.

18

For factor (b) that relates to overheated heat transfer fluids, the WSH (General Provisions) Regulations has requirements for pressurised heating systems in the form of steam boilers, steam receivers and steam containers¹¹. However, there are no requirements for heating systems (pressurised or otherwise) that rely on other types of heat transfer fluids. As seen in this accident, combustible liquids with high flash points (greater than 150 °C) could still pose a significant hazard under certain conditions. Therefore, it is recommended that heating systems that use combustible liquids should also be appropriately assessed with suitable control measures implemented (e.g. pressure monitoring, pressure relief venting) and that this can be done in conjunction with the above recommendation regarding closed systems.

¹⁰ Factors related to equipment ergonomics, equipment safety information and improper risk assessment have been omitted as they have been discussed in the previous Section.

¹¹ WSH (General Provisions) Regulations 28 to 30.

2 Currently, the only Singapore standard that defines and addresses hazards posed by combustible
liquids is SS 532¹², which is an ACOP applicable to all workplaces defined within the scope of the
standard. This standard provides guidance on the storage of flammable and combustible liquids with
4 flash points of up to 150 °C. The requirements in SS 532 concern storage quantities, conditions of
storage (e.g. ventilation, drainage), fire-fighting, emergency response, separation distances and wall
6 fire-ratings. The standard's scope does not cover flammable or combustible liquids that are used in
processes or is an integral part of the processing plant or equipment. Moreover, there is also a lack
8 of guidance documents available internationally in the area of flammable mists from high flashpoint
fluids. For example, even though NFPA 30¹³ does provide some useful information on safety
10 measures for handling and use of combustible liquids under process conditions, its scope specifically
excludes mists and sprays. Furthermore, NFPA 30B¹⁴ is not directly relevant as it is meant for aerosol
12 products (e.g. spray cans).

14 There is therefore a significant gap in the standards framework for flammable and combustible
liquids used in processes and in particular combustible liquid aerosols. This gap is partially due to
16 knowledge gaps in the areas of mist flammability, mist generation and mitigation measures¹⁵ for such
combustible liquid aerosols. It is therefore recommended that the Chemical Standards Committee
18 look into the feasibility of developing a standard to prevent fires and explosions from combustible
liquid aerosols. The committee should also look into the research needed to close the knowledge
20 gaps for the development of such a standard.

22 With reference to factor (c), Regulation 26 of the WSH (General Provisions) Regulations stipulates
the precautions for dealing with explosive or flammable dust, gas, vapour or substance. In this
24 accident, the decomposition of HTF could have resulted in the generation of flammable gasses and

¹² SS 532 (2016): Code of practice for the storage of flammable liquids (published by Enterprise Singapore).

¹³ NFPA 30: Flammable and Combustible Liquids Code (published by the National Fire Protection Association, USA).

¹⁴ NFPA 30B: Code for the Manufacture and Storage of Aerosol Products (published by the National Fire Protection Association, USA).

¹⁵ Gant, S., et al., (2013). Generation of flammable mists from high flashpoint fluids: literature review. Health and Safety Executive, Research Report RR980.

1 vapours and it is incumbent on users of such materials to be aware of this possible hazard and
2 implement the measures stated in Regulation 26. In addition, under certain conditions, a
combustible liquid could be aerosolised and be ignited to cause fires or explosions. Under Regulation
4 26, such a liquid aerosol could be broadly described as a “substance... of such a character and is to
such an extent as to be liable to explode on ignition” and such that it would therefore come under
6 the regulatory requirements. However, to make it clearer, it is recommended that the terms
“combustible liquid aerosols” and “flammable gases and vapours arising from material
8 decomposition” should be included and be made explicit in Regulation 26.

10 In terms of standards, there are no guidance documents available both locally and internationally
that deal with the issues around hazards arising from thermal decomposition of materials (solid and
12 liquids). Therefore, it is also recommended the Chemical Standards Committee look into the
feasibility of developing a standard addressing the preventive and control measures for flammable
14 gasses and vapours generated from the thermal decomposition of materials (solid and liquids).

16 Finally, for factor (d), it is noted that there is a general lack of awareness and knowledge around
thermal runaways, material decomposition hazards and liquid aerosol explosions. There should
18 therefore be guidance material and training developed for industry practitioners (e.g. WSH officers)
and SMEs to address these topics. Without a reasonable level of technical knowledge, risk
20 assessments conducted would inevitably overlook hazards associated with thermal runaways,
material decomposition hazards and liquid aerosol explosions. This subsequently leads to the
22 necessary control and mitigation measures not being implemented.

24 3.3 Item (4) – Release and formation of liquid aerosols

The possible factors related to the release and formation of liquid aerosols are listed as follows:

- 26 a. Overpressure – vapour and gasses generated from overheating and decomposition of HTF
- b. Overheating – thermal expansion of gasses/vapours
- 28 c. Overfilling – overpressure due to thermal expansion of liquids

- d. Corrosion, material fatigue – metal degradation from chemicals and temperature cycling
- e. Poor maintenance – quality of repairs
- f. Accidental release, puncture – human error and impact hazards

Aspects to be addressed related to factors (a), (b) and (c) have been discussed in the previous Section 3.2. In terms of corrosion, metal fatigue and maintenance issues (factors (d) and (e)), Section 12 of the WSH Act has provisions that requires employers to maintain a safe work environment.

There are also requirements for the maintenance of steam boilers/receivers/containers, air receivers, pressure vessel, pipes (including conveyance equipment) and gas plants that have been stipulated in the WSH (General Provisions), under Regulations 28 to 31 and 33 to 35. Therefore, in alignment to the previous recommendations for heated systems that are operated: (i) in a closed configuration; and/or (ii) using combustible liquids, maintenance of such systems should also be explicitly stated in the WSH (General Provisions) Regulations to strengthen and clarify the general maintenance requirement under the WSH Act.

Finally, in terms of the contribution of human error and impact hazards (factor (f)), these are currently adequately tackled by means of:

- Ergonomics – WSH Guidelines: Improving Ergonomics in the Workplace published by the WSH Council
- Behavioural safety – WSH Guide to Behavioural Observation and Intervention published by the WSH Council
- Promotional and awareness campaigns – Vision Zero Movement launched by the WSH Council

In addition, recommendations made previously in Section 3.1 on machine ergonomics and safety will also have addressed human errors through distinguishing touch points and anticipating misuse. Hence, no further recommendations are needed here.

3.4 Item (5) – Combustible dust

2 The factors identified that could contribute to a combustible dust flash fire or explosion are as follows:

- 4 a. Equipment failure – overpressures leading to dispersion of stored powders of accumulated surface dust.
- 6 b. Primary explosion – initial deflagration suspending accumulated dust and dispersing stored powdered material
- 8 c. Excessive air velocity – suspension of accumulated dust on surfaces
- 10 d. Improper hazard identification and risk assessment – overlooking the potential for combustible dust hazards

12 For the three factors (a, b and c) identified, there are requirements within the WSH (General Provisions), Regulation 26 that stipulate precautions for processes in a workplace that give rise to dust to such an extent as to be liable to explode on ignition. In addition, detailed control and mitigation measures are also described in SS 667¹⁶.

16
18 SS 667 was developed as a best practice reference especially for SMEs (small and medium-sized enterprises) on the handling and storage of various types of combustible dust in the context of high-rise, multi-storied, multi-tenanted and below ground facilities that are typically found in land scarce Singapore. This standard was developed by a working group with myself as convenor.

22 The standard aligns the requirements from various local regulatory agencies with regards to fire, explosion and other hazards related to combustible dusts so as to achieve better clarity and facilitate compliance. In addition, it is also meant to support the creation of new business opportunities by creating a safe operating environment for emerging industries such as additive manufacturing.

26
28 SS 667 provides guidance in the areas of dust hazard identification, characterisation and analysis, hazard management via mitigation and prevention, process equipment safety specifications, storage

¹⁶ SS 667 (2020): Code of practice on handling, storage and processing of combustible dust.

2 requirements, facility and system design including performance-based design options as well as
safety management system implementation.

4 In terms of risk assessments, the current requirements under WSH (Risk Management) Regulations
and the RMCP are general in scope but they should in effect, cover combustible dust hazards.
6 However, in practice, combustible dust hazards are usually overlooked by risk assessors due to their
seemingly innocuous characteristics and forms (e.g. milk, sugar, starch). In some jurisdictions, in
8 order to overcome this inherent bias, a more specific risk assessment focussing on combustible dust
have been mandated, for example OSHA's¹⁷ Dust Hazard Analysis. SS 667 provides similar guidance
10 in terms of assessing the risks from combustible dust. However, compliance to this standard is
currently voluntary with the exception of its provisions relating to fire safety that are now required
12 for SCDF's building plan submissions effective 1st December 2021. It is therefore recommended that
SS 667 be gazetted as an ACOP under the WSH Act with the relevant changes made to the RMCP to
14 reference and integrate SS 667's DHA as part of the overall risk assessment regime.

¹⁷ OSHA: Occupational Safety and Health Administration of the United States of America.

4 Conclusion

2

The accident at Stars Engrg involved a primary deflagration caused by the ignition of aerosolised
 4 combustible liquid (i.e. HTF) followed by secondary flash fires from combustible dust. An FMEA was
 conducted to systematically analyse and identify gaps within the regulatory requirements and
 6 supporting standards. The results from this FMEA can be classified into two main types of
 recommendations namely regulatory requirements and standards, guidance material and training as
 8 summarised in **Table 1** and **Table 2** below.

10

Table 1: Summary of recommendations on regulatory requirements

	Legislation	Recommendations
1	WSH Act, Section 16 - general duties of manufacturers and suppliers of machinery, Fifth Schedule	Include coverage for heated equipment or equipment with energy inputs into closed systems that could result in overheating or overpressure.
2	WSH Act, Section 17 – installation of equipment	Enhance with the inclusion of key commissioning components such as equipment/process design and information review, determination of system boundary limits, inspection and acceptance testing, safe start-up and documentation.
3	WSH (General Provisions), Regulation 26 - explosive or flammable dust, gas, vapour or substance	The terms “combustible liquid aerosols” and “flammable gases and vapours arising from material decomposition” should be included and be made explicit.
4	WSH (General Provisions)	Include suitable control measures (e.g. pressure monitoring, pressure relief venting) and maintenance requirements in relation to the use of heating systems where such heating systems are operated: (i) in a closed configuration; and/or (ii) using combustible liquids.
5	WSH Act, Section 40B	SS 667 to be gazetted as an ACOP.

Table 2: Summary of recommendations related to standards, guidance material and training development

	Standards, guidance and training	Recommendations
1	SS 537: Code of practice for the safe use of machinery – Part 1: General requirements	Review to cover: a. Heated equipment (e.g. the mixer machine) with reference to ISO 12100. b. Guidance on “Information for Use” to address the quality of safety information provided by the manufacturer and suppliers of equipment.
2	New guidance document and training	Develop a guidance document with the relevant industry association (e.g. SMF) on commissioning best practices for SMEs as a resource and as a basis of training programme.
3	RMCP	a. Review the RMCP and include guidance and examples to enable better identification of process related hazards (e.g. overpressure, decompositions, combustible liquid aerosol). b. Reference and integrate SS 667’s DHA as part of the overall risk assessment regime.
4	New Standards	CSC to look into: a. Feasibility of a standard to prevent fires and explosions from flammable and combustible liquids used in processes and in particular combustible liquid aerosols; b. Feasibility of a standard addressing preventive and control measures for flammable gasses and vapours generated from the thermal decomposition of materials (solid and liquids); and c. Research needed to close the knowledge gaps for the development of such a standard.
5	New guidance material and training	Create awareness of hazards associated with thermal runaways ¹⁸ , material decomposition hazards and liquid aerosol explosions.

¹⁸ Exothermic reaction where the heat generated exceeds the heat removed and this surplus heat then further accelerates the reaction and heat production.

References

SSC (2020). Code of practice for the handling, storage and processing of combustible dust. SS 667, Singapore Standards Council.

2 SSC (2008). Code of practice for the safe use of machinery – Part 1: General requirements. SS 537, Singapore Standards Council.

4 SSC (2016). Code of practice for the storage of flammable liquids. SS 532, Singapore Standards Council.

6 SSC (2018). Occupational health and safety management systems — Requirements with guidance for use. SS ISO 45001, Singapore Standards Council.

8 NFPA (2021). Flammable and combustible Liquids Code. NFPA 30, National Fire Protection Association.

10 NFPA (2019). Code for the Manufacture and Storage of Aerosol Product. NFPA 30, National Fire Protection Association.

12 ISO (2010). Safety of machinery — General principles for design — Risk assessment and risk reduction. ISO 12100, International Standards Organisation.

14 WSH Council (2015). Code of practice on workplace safety and health (WSH) risk management (RMCP). Workplace Safety and Health Council.

16 Gant, S., et al., (2013). Generation of flammable mists from high flashpoint fluids: literature review. Health and Safety Executive, Research Report RR980.

Appendices

Appendix A: Key components of the accident block flow diagram

Appendix B: Failure Mode and Effect Analysis (FMEA) of the key components from the accident

Appendix A: Key components of the accident block flow diagram

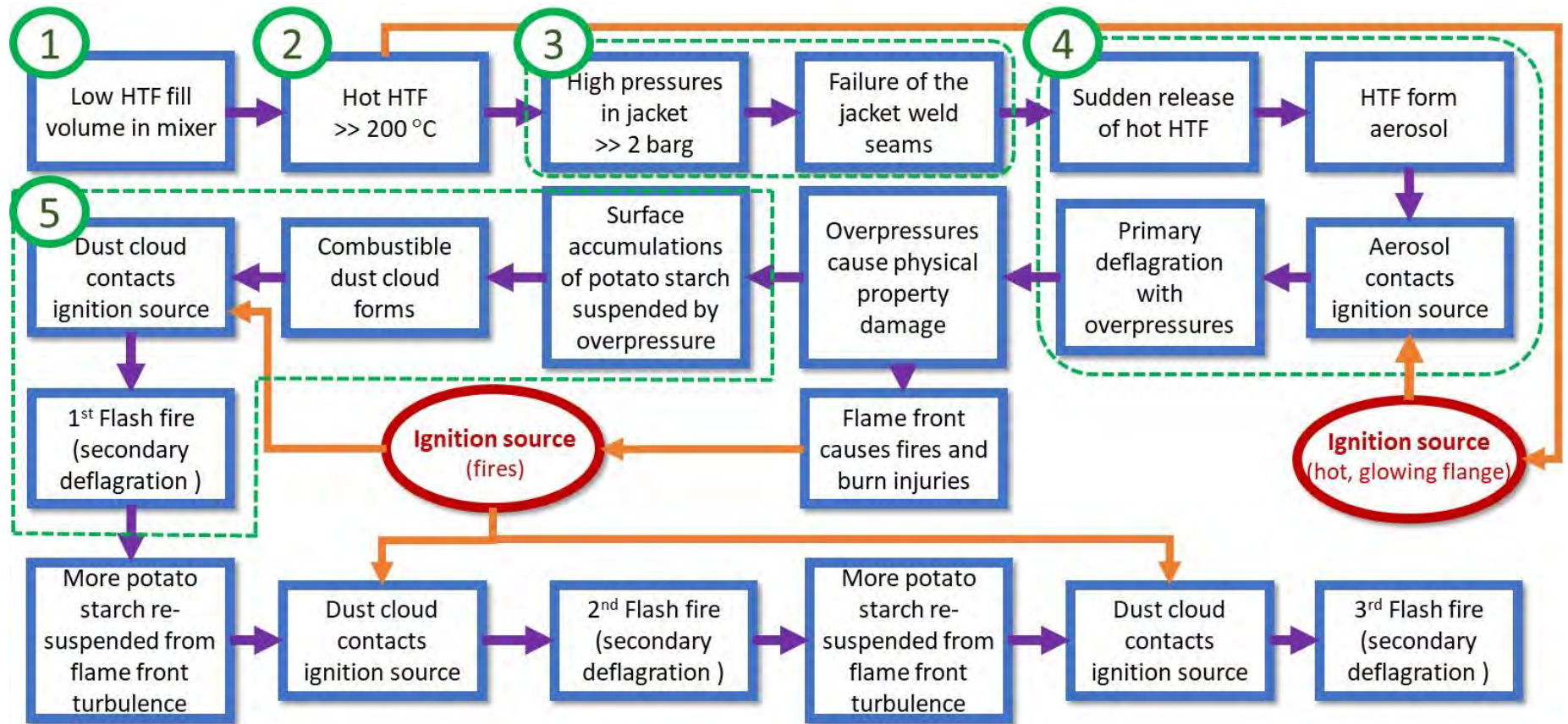


Figure A.1: Block flow diagram indicating the accident's sequence of events

Appendix B: Failure Mode and Effect Analysis (FMEA) of the key components from the accident

Operation/ Item	Failure Mode	Cause	Consequence	Existing Controls	Recommendations
1. HTF fill in heating jacket	Low HTF volume	Equipment ergonomics	Overheating of HTF	WSH Act, SS 537 Part 1	Need to include heated equipment, closed systems with energy inputs that could result in overheating/overpressure
		Equipment safety information, Hazard communication		WSH Act- Section 16	Need to include heated equipment, closed systems with energy inputs that could result in overheating/overpressure
					Guidance or standards on communication of equipment hazard/safety information
		Improper risk assessment		WSH (Risk Mgt) Reg. & RMCP	RMCP refers to more task/ activity-centric risk assessment. May overlook process type interactions
		Improper equipment commissioning		WSH Act- Section 17	Training, guidance on commissioning best practices
		Poor/missing SOP		WSH Act, RMCP, SS-ISO 45001 cover SWP	NIL

(Continued)

Operation/ Item	Failure Mode	Cause	Consequence	Existing Controls	Recommendations
2. Heating of HTF	Overheated HTF	Equipment ergonomics	Decomposition of HTF, high pressure in jacket	WSH Act, SS537-Part 1	Need to include heated equipment, closed systems with energy inputs that could result in overheating/overpressure
		Equipment safety information, Hazard communication		WSH Act-Section 16	Need to include heated equipment, closed systems with energy inputs that could result in overheating/overpressure
					New guidance or standards on communication of equipment hazard/safety information
		Improper risk assessment		WSH (Risk Mgt) Reg. & RMCP	RMCP refers to more task/ activity-centric risk assessment. May overlook process type interactions
		Improper equipment commissioning		WSH Act-Section 17	Training, guidance on commissioning best practices
		Poor/missing SOP		WSH Act, RMCP, SS-ISO 45001 cover SWP	NIL

(Continued)

Operation/Item	Failure Mode	Cause	Consequence	Existing Controls	Recommendations
3. Heating jacket integrity	Overpressure in jacket	Closed system with no venting, pressure monitoring	Vessel rupture, loss of containment, generation of combustible liquid aerosols	WSH (GP) Reg covers only pressure vessels	Needs to have provisions for closed systems that could result in overpressure under operational deviations
		Overheating of HTF		WSH (GP) Reg. 28-30 covers pressurised heating systems using steam	<ul style="list-style-type: none"> Need to cover other types of heating systems CSC to look into flammable and combustible liquids used in processes and in particular combustible liquid aerosols
		Decomposition of HTF		WSH(GP) Reg. 26	<ul style="list-style-type: none"> WSH(GP) introduce language related to hazards arising from decomposition of materials and liquid aerosols CSC to look into flammable gasses and vapours generated from the thermal decomposition of materials
		Equipment design, not pressure vessel		WSH Act, SS537 Part 1	Need to include heated equipment, closed systems with energy inputs that could result in overheating/overpressure
		Equipment safety information, Hazard communication		WSH Act-Section 16	Need to include heated equipment, closed systems with energy inputs that could result in overheating/overpressure Guidance or standards on communication of equipment hazard/safety information
		Improper risk assessment		WSH (Risk Mgt) Reg & RMCP	RMCP refers to more task/ activity-centric RA. May overlook process type interactions
		Lack of technical knowledge		NIL	Training, guidance on aerosols, chemical decomposition hazards
		Faulty repairs, welding		Lack of competency	Weakened weld seams

(Continued)

Operation/Item	Failure Mode	Cause	Consequence	Existing Controls	Recommendations
4. Release and formation of liquid aerosols	Sudden, accidental structural failure	Overpressure	Fire, explosion	WSH (GP) Reg covers only pressure vessels, WSH (Risk Mgt) Reg & RMCP	<ul style="list-style-type: none"> Needs to have provisions for closed systems that could result in overpressure under operational deviations Standards for combustible liquid aerosols Aerosol hazard assessment into RA
		Overheating		WSH (GP) Reg. 28-30 covers pressurised heating systems using steam	<ul style="list-style-type: none"> Need to cover other types of heating systems CSC to look into flammable and combustible liquids used in processes and in particular combustible liquid aerosols
		Overfilling		WSH (GP) Reg covers only pressure vessels	Needs to have provisions for closed systems that could result in overpressure under operational deviations
		Corrosion, material fatigue		WSH Act Section 12 - maintenance	NIL
		Poor maintenance		WSH Act Section 12 - maintenance	NIL
		Accidental release, puncture		WSH Guidelines – Ergonomics, Behavioural Safety, Vision Zero	NIL

(Continued)

Operation/ Item	Failure Mode	Cause	Consequence	Existing Controls	Recommendations
5. Combustible dust	Combustible dust ignition	Equipment failure	Combustible dust flash fire, explosion	WSH (GP) Reg & SS 667	SS 667 to be gazetted as ACOP
		Primary explosion		WSH (Risk Mgt) Reg & RMCP	DHA from SS 667 to be incorporated into RMCP
		Excessive air velocity		SS 667	SS 667 to be gazetted as ACOP
		Presence of ignition sources e.g. electrical, hot surface, electrostatic		SS 667	SS 667 to be gazetted as ACOP

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Mission | We advance science and develop innovative technology to further economic growth and improve lives.

Vision | A global leader in science, technology and open innovation.

THE SMF'S INPUTS ON EXPLOSION INCIDENT AT 32E TUAS AVENUE 11

The SMF is pleased to submit the following written comments and recommendations for the Inquiry Committee's considerations.

1 Enhance public and private partnership to ensure a safe and conducive workplace

1.1 While the SMF recognises the authorities' efforts in enforcing policies and regulations to ensure a safe regulatory framework at work, we believe that the organisations, including SMEs should also share responsibilities to ensure the workers' safety through for examples, self-implementing guidelines, practices, and standards, given that there is no one-size-fits-all regulatory policy for supporting SMEs due to their heterogeneous nature. The SMF would also like to add that we are mindful to seek a balance between the additional mandatory requirements and to protect organisations, especially SMEs' interest and needs, and not to cause undue burden to them, in particular where businesses are largely impacted by the recent Covid-19 pandemic.

1.2 In this regard, the SMF as the leading Manufacturing Federation could serve as a conduit to connect between the authorities and the manufacturing industries to co-develop, educate, and promote relevant safety standards to the industries, through SMF-Standards Development Organisation appointed by Enterprise Singapore and our network with the wide industry stakeholders.

1.3 In particular, the SMF would be keen to work with MOM, and other key organisations such as Enterprise Singapore, Singapore Institution of Safety Officers, National Safety Council of Singapore, Workplace Safety and Health Council etc. to further promote and create awareness of safety standards and culture in the workplace.

2 Setting baseline standards to ensure the workplace safety, safe use of machineries, storage, and handling of combustible dust

Singapore Standard (SS) 537-1 Code of practice for safe use of machinery – General requirements

2.1 The SS 537-1 provides comprehensive guidelines on the methods for safeguarding the dangerous parts of machinery and enhancing safety in the use of machinery.

It also provides:

- basic requirements on the design and manufacture of machinery so as to ensure that machinery used locally is incorporated with basic safety features; and
- guidelines on the safety and health issues relating to the installation, testing, maintenance and servicing of machinery.

2.2 The SMF would like to suggest reviewing the SS 537-1 to incorporate any latest requirements following the incident to ensure the safe commissioning, operation, maintenance, and repair of industrial machines operating in a similar manner as that involved in the incident. In consultation with the industry stakeholders, it is noted that the current SS 537-1: 2008, which is an Approved Code of Practice under WSHC would help the company to ensure safe operation and use, given that the standard covers the following:

- Clause 4.1, as far as reasonably practicable, the user should only procure machinery that has been designed and constructed with adequate safety consideration accounted for. The user shall carry out a risk assessment to identify the residual hazards and provide for the necessary controls to eliminate or mitigate the residual risks or injury;
- Clause 5 on principles of risk assessment and reduction (e.g. 5.2.3 states risk assessment shall be carried out before work is allowed to commence on any machinery, it includes a schematic representation of the iterative process for eliminating hazards and implementation of safety measures);
- Clause 6 on hazard management and checks by users;
- Clause 8 on installation considerations;
- Clause 9 on maintenance; and
- Clause 10 on safe work practices. (It states that in developing safe work practices, the manufacturers' instructions and information must be taken into account, 10.3 on supervisory control)

SS 667 Code of Practice for Handling, Storage and Processing of Combustible Dust

2.3 On the handling, storage and processing of combustible dust, the SS 667 is to be referenced to provide requirements and recommendations to prevent fire and explosion hazards resulting from the ignition of fine solid particulates that are suspended within an enclosure or building.

2.4 The SS 667 details the steps to ensure the Dust Hazard Analysis (DHA) and Process Hazard Analysis shall be made compulsory at all facilities using combustible dust such as, but not limited to additive manufacturing, food

processing, petrochemicals, pharmaceuticals etc., It requires DHA to include tests for determining combustibility/explosibility, mitigation measures, housekeeping, and periodic and random checks to ensure that the measures are effective.

2.5 Under the requirements of SCDF, the SS 667 shall be applicable to all building plans that are submitted to SCDF for approval from 1 December 2021.

2.6 Additionally, for Additive Manufacturing Facilities operating in Singapore, the adoption of Technical Reference 87 (Safety of Additive Manufacturing Facilities) should be encouraged. This is because the majority of these AM facilities use metal and polymer powders, which are combustible and reactive (such as Titanium, Aluminium etc.).

2.7 The SMF will like to recommend that the WSHC consider adopting the SS 667 and the TR 87 as an Approved Code of Practice.

ISO 45001 Occupational Health and Safety Management Systems – Requirements with guidance for use

2.8 The MOM has required certain workplaces to implement a safety and health management systems, including risk assessment and risk management. The implementation of ISO 45001 requirement provides a framework to prevent accidents. An organization is required to establish a process to report, investigate, and take action(s) to control and correct the incident or nonconformity to prevent any recurrence or occurrence. In this incident, despite a series of “red flags” that happened a few months before the explosion occurred, there was no proper investigation conducted. Consultation and participation of workers should be emphasized. Feedbacks should be addressed so that preventive measures could be put in place and corrective action taken promptly. The reception of suggestions would be more effective if workers did not fear the threat of dismissal, disciplinary action or other such reprisals when making them.

2.9 All (whether imported or locally built) machines purchased for used in the workplace should be fit for its purpose in terms of functional and safety aspects. The clause 8.1.4 of ISO 45001 ensures that the process for procuring any products (machines, equipment etc.) from external providers need to include OH&S controls, verified safe for use for workers before being introduced into the workplace.

Other safety standards

2.10 The SMF will also like to suggest that other machinery safety and combustible dust standards such as IEC 62071, ISO 13489, NFPA 652, 654, 484, 499 or equivalent could also be reviewed to see whether they are applicable for Singapore’s context, and be adopted as an Approved Code of Practice by the WSHC. Relevant procedures regarding the safe commissioning, operation, maintenance, and repair of the machines shall be established and followed. This can be borrowed from many other industries such as automation industry and process industry.

3 Advocating the role of Testing, Inspection, and Certification

3.1 Under the SMF, a Testing, Inspection and Certification (TIC) Interest Group has been set up since 2016, to serve and advance the interests of the testing, inspection and certification industry in Singapore. The SMF will be keen to work with the authorities and key stakeholders to develop and provide recommendations to industry players on new or updated TIC services that can support national or industry initiatives. For e.g. for added safety and quality, machines which are sourced outside Singapore could be subjected to third party Inspection services before shipment to Singapore.

4 Other safety considerations

4.1 In addition, the SMF will also like to suggest aligning across certain factories with certain thresholds (certain scale and certain sectors) that would require an in-house safety manager. The safety manager could take responsibility to report independently on all safety and machine matters to the authorities to ensure safety concerns.

4.2 Procurement of industrial equipment should be also be done through reputable companies / suppliers, vetted by the end-user.

- Proper and full documentation of the equipment should be provided by the seller, including standard operation manual and practical maintenance procedures.
- Equipment or machine training by OEM or its regional representative if possible.

4.3 From machinery safety perspective, electrical fire hazard is one of the hazards that need to be taken into serious consideration. To evaluate various machinery design aspects, e.g. suitable protective devices (MCB etc.), creepage & clearance & insulations – for electric shock protection, material – to prevent spread of fire, fault simulations – for foreseeable misuse, etc. Compliance to machinery safety requirements is an important regime/step to ensuring proper consideration of the safety and application of the machinery are being carried out. However, this is just the upstream (inherent safety) consideration.

4.4 In addition, the machines shall be subjected to Field Safety tests at the “Point of Installation”. That is, after the equipment is installed & commissioned in the SG facility, they shall be subjected to Field Evaluation and continuous operation tests. Only upon successful completion of Field Evaluation of the installed equipment, that the facility be allowed to function.

4.5 The possibility of operating at the allowable stress levels (or the maximum permitted values of operating parameters such as speeds, voltages, current, temperatures etc.) must be examined and ensured safe. Function test of the equipment should be conducted prior to commissioning. Running time can be set by the user to monitor the operating parameters of the equipment. Some key parameters to take note could be:

- Temperature
- Noise
- Electrical stability

4.6 A Daily/Weekly/Monthly/Yearly service record and maintenance checklist should be prepared, used, and archived to allow traceability of the condition of the equipment.

4.7 Routine inspection and periodical non-destructive test can be conducted on key components of equipment to examine its serviceability, in particular welds and joints.

4.8 Operators should be well trained in both the technical and safety aspects of the equipment.

4.9 All staff should be briefed on emergency procedures and designated first-aiders should be present on-site during operation of the equipment.

4.10 Improvised repair and maintenance procedure should be assessed and approved by relevant individual.

4.11 Modification on industrial machines should be in accordance with the manufacturer’s manual.

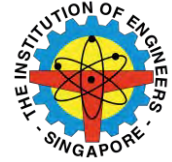
4.12 Stricter measures shall be implemented to prevent the practice of those who interfere with/alter the basic machine design/configuration, thus compromising the safety of the equipment, of the operating personnel and the facility that houses it and other co-occupants.

4.13 As a last line of defence, the use of appropriate PPE must be made mandatory. It is not clear whether the operators in the Tuas explosion were wearing Fire Retardant work clothes (compliant to NFPA2112 or the equivalent), safety goggles, heat resistant gloves etc., at the time of explosion. Probably, that would have reduced the extent of burn injuries thus preventing fatalities. The presence of a “slipper” at the accident site needs to be looked at.

5 Conclusion

The SMF expresses our regret for this unfortunate incident. We stand firm to work closely and to support the authorities and all concerned so that we can learn from this incident and build further appropriate safeguards to prevent future incidents.

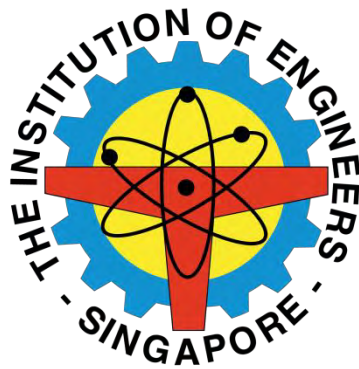
Work place Safety & Health is a mindset, that can only be enhanced with both Awareness and Education. This mindset cannot be regulated into, nor via increasing costs of regulations and certifications, though that is necessary in itself. The SMF knows that there is still a journey ahead to find this balance between a workplace that is both Innovative and Safe.



Written Submission to Inquiry Committee into the Explosion at 32E Tuas Avenue 11

Prepared by

The Institution of Engineers, Singapore





Ministry of Manpower
Occupational Safety and Health Division
1500 Bendemeer Road #03-02
Ministry of Manpower Services Centre
Singapore 339946

Written Submission from The Institution of Engineers, Singapore (IES) In Response To The Explosion At 32E Tuas Avenue 11

Overview:

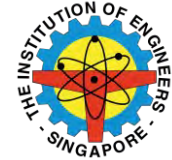
In response to the invitation from the Ministry of Manpower (MOM) to submit a written representation with regards to the fatal explosion and fire at 32E Tuas Avenue 11 on 24 February 2021, in particular in relation to part (b) of the Terms of Reference (TOR) provided by MOM i.e. on recommendations to prevent the recurrence of such an accident at workplaces, IES is putting forward its feedback and recommendations for MOM's consideration.

To prepare this submission, IES had organised a few rounds of expert consultations, discussions and verifications within the engineering faculty to ensure the accuracy and comprehensiveness of our feedback and to professionally assess and review the subject matter.

The recommendations herewith take into consideration the impact on the industry in terms of safety, the practicality in terms of implementation as well as the operational and business impact to the industry, especially for small and medium enterprises (SMEs).

This submission is the outcome of discussions by an IES Expert Committee comprising the following engineering experts / practitioners from related industries:

- 1. Er. Chong Kee Sen (Chairman)**
Emeritus President, IES
Director, Engineers 9000
- 2. Mr. Jason Oh (Facilitator)**
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Chairman, Vision Zero Committee and Past Chairman of Health & Safety Engineering
Technical Committee, IES
- 3. Er. Au Kow Liong**
Council Member, IES
Managing Director, K L Au Consultants Pte Ltd
- 4. Dr Foo Swee Cheng**
Ex. Council member, IES
Past Chairman of Health & Safety Engineering Technical Committee, IES

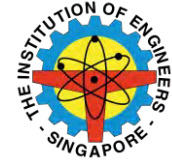


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Managing Director, DLM Pte Ltd
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Council Member, IES
Director, Professional Officers Division, Singapore Institute of Technology
- 10. Mr. S. Yogeewaran**
Council Member, IES
Managing Director, CASY Engineering Consultancy Pte Ltd
- 11. Dr. Teo Tee Hui**
Council Member, IES
Faculty in-charge for Electrical Power Systems & Electronics Design Laboratory, SUTD

Statement of Limitation:

The submission, however, is made with the understanding that IES' feedback stands as professional and industry recommendations for the purpose of the inquiry and with no legal implication or enforceability. In addition, IES has made use of available information to make certain assumptions with respect to conditions/scenarios that may exist in the future. While IES believes the assumptions made are reasonable for the purposes of the submission, it makes no representation that the conditions/scenarios assumed will occur in the present or future.



Feedback and Recommendations

Our feedback and proposed recommendations are based on the following scope from MOM:

- (a) Measures to ensure the safe commissioning, operation, maintenance, and repair of industrial machines operating in a similar manner as that involved in the incident; and
- (b) Measures to ensure the safe supply, storage and handling of combustibile dust or powders at workplace settings similar to that involved in the incident.

Here are our feedback and proposed recommendations:

1. What additional statutory regulations (if any) for the design, purchase, installation, operating and maintenance of such or similar mixer machines should be put in place?

- The existing WSH Act especially under Section 16 has covered duties of manufacturers and suppliers comprehensively. However, actual implementation is important and there is a need to introduce multi-layer preventive measures that are robust but yet practical enough to exercise to safeguard the safety and health of workers at the workplace. However, smaller factory operators may not be fully aware of safety guidelines and requirements and may also not strictly follow such guidelines. Thus, more needs to be done to educate and motivate smaller factory operators to understand and comply with existing regulatory requirements.
- Manufacturers and suppliers act according to information provided by equipment owners/operators who may ask to maintain a high degree of confidentiality with respect to their activities. However, owners/operators must provide essential safety information including definition of process material(s) for both intended normal and anticipated abnormal operating conditions.
- We propose that the committee consider requiring design and installation of such or similar equipment, before it is being put into use, to be reviewed by at least one competent third party coming from the perspectives of the fire department, risk insurance, Professional Engineer (PE) registered by Professional Engineers Board (PEB) or Chartered Engineer or Chartered Technologist registered by IES.
- This would require a re-look into categorizing such or similar equipment that requires the said competent person to review the installation, testing and certification before such machines are put into use. The categorization should take a risk-based approach. This would mitigate the risk where safety provisions in the installation are ignored.
- Additionally, for the operation of such machines, owners/operators have to appoint a qualified engineer, technologist or technician as the approved operator who has to be registered and has undergone continuous training to operate machineries competently.



- The owner should direct the approved operator to keep a record on the maintenance, repairs and fault incidents throughout the operating life span of the machine. Any changes to the machine processes or materials must go through a 'management of change' process to determine if the combustible dust risk will be altered. If it is, or if there is any doubt, an updated review from a competent third party is required.
- As there are factory operators of various organisational sizes, consideration needs to be made when rolling out blanket guidelines/regulations that could have impact on the business operations, especially for small factory operators. We propose for MOM to set certain categories and define guidelines relevant for different sizes and types of equipment and levels of potential risk. For example, a small factory operator processing less than 100 kg of highly combustible dust in a densely populated area may be potentially more hazardous than a large factory operator processing a significant amount of the same material in a remote and automated manner. The environment and location of a combustible dust process are very significant factors with respect to the threat to human life.
- While there should be adequate safeguards to ensure safety, it should not be over-regulated. Equipment could be categorised according to the level of potential risk but it has to be recognised that it is not practical to define and categorise all equipment.

2. What additional statutory regulations or requirements for the storage and handling of powder that has powder explosive potential should be put in place?

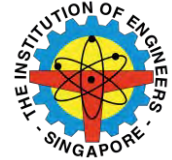
- Dust as a hazard is presently not fully covered under the major hazards installation (MHI). It is time to place more attention to close this potential risk gap in Singapore.
- We recommend incorporating SS 667:2021 to be gazetted as an Approved Code of Practice (ACOP) as a requirement before making it a mandatory at a later phase.
- The National Fire Protection Association (NFPA) has good Standards that provide requirements on combustible dust risk mitigation by the type of industrial application. The NFPA Standards also define the recognised means of providing combustible dust explosion prevention and protection in Standards NFPA 68 (2018 edition) and NFPA 69 (2010 edition). It specifies clearly the type of equipment that needs to be protected such as silo, elevator, mixer and milling equipment. We recommend that this could be considered for adoption.
- NFPA 652 – Training of personnel with timeline to do their own dust hazard analysis. We recommend for MOM or the relevant agency to review and adopt this and that such activity is repeated every five years or less or when a process change is planned.



- We also recommend for plants that operate with potential combustible dust to comply with SS 667 and NFPA codes.
- NEA presently regulates dust collector equipment as a means to mitigate pollution only. However, dust collectors are also a potential source of dust explosion. We recommend that the potential risk of dust explosion arising from dust collectors should also be reviewed by the relevant agencies, for example SCDF and MOM.
- As mentioned earlier, there are still grey areas and gaps that need to be addressed with regard to dust explosion potential. We recommend that a committee consisting of relevant government agencies, industry practitioners and academia to review and relook the good practices and propose a regulatory frame work where required.
- As an example, the following requirements for Dust Machine/Equipment could be put in place:
 - Classification of Equipment/Machinery handling dust / powder to have IECEx / ATEX / FM Certification as part of commissioning
 - Requiring statutory periodic IECEx-certification / ATEX / FM (annual, biannual, 3-yearly) to be part of Factory-license/MHI-license

3. Recommendations to strengthen the training, CET, accreditation of person operating such equipment.

- We propose to tap on the established IECEx certification scheme to train competent personnel who can specialise in dust explosion risk which includes modules on maintenance, dust risk assessment, zoning and operation. The scheme covers functional safety areas as well. This approach might be easier to introduce to the industry as IECEx courses are also available in Singapore. Such training could be managed by the IES Academy. Engineers, technologists and technicians with a background in electrical and mechanical engineering will benefit from these courses. With a competence-based and peer-review registration scheme, IES could assist in the registration of such engineers, technologists and technicians.
- Existing WSH training related to factories with risk of combustible dust should also be updated to ensure that all personnel are aware of dust hazards. Some examples include "Apply Workplace Safety and Health in Metal Work" and "Apply Workplace Safety and Health in Process Plant".
- Continued education and sharing form the cornerstone for the competency and safety of all personnel. Learned Institutions such as IES could collaborate with MOM and SCDF or any other relevant agencies through knowledge exchange where agencies could share or provide more data / information on local accidents so that suitable recommendations can be made for trainings.



- We recommend that a system be put in place regarding the requirements for Personnel Competency. For example:
 - Dust Equipment / Machine Functional-Certifier / Inspector (IECEX)
 - Operator Competency on dust explosion awareness / operation-level
- We also recommend that a system be put in place regarding the requirements for Company Management. For example:
 - Mandatory to conduct DHA and implement control measure to ALARP
 - Mandatory to appoint Dust Competent Person for their site / operation.
 - Mandatory to conduct Management Of Change reviews

About IES:

The Institution of Engineers, Singapore (IES) was formally established in July 1966 as the national society of engineers in Singapore. IES is the premier engineering institution in Singapore and is called upon by the Government to provide feedback on professional engineering matters.

IES is well represented among the faculty members of the major engineering institutions of higher learning in Singapore. Through close collaboration with the local universities and polytechnics, IES organises courses, seminars and talks for engineers and IES members to advance the continuous development of engineers.

The Institution maintains close links with professional organisations of engineers regionally and throughout the world. These include organisations in Australia, China, Japan, United Kingdom and the United States. The Institution also represents Singapore in the ASEAN Federation of Engineering Organisations (AFEO) and the Federation of Engineering Institutions of Asia and the Pacific (FEIAP) in promoting goodwill and fellowship among all engineers in ASEAN and the Asia-Pacific region.

Through its Engineering Accreditation Board (EAB), IES obtained full signatory status in the Washington Accord (WA) in June 2006. The entry grants IES the authority to represent Singapore, the first country within the ASEAN region which has obtained full signatory status in the WA, to vet education systems under the WA mutual recognition framework.

For more info, visit www.ies.org.sg

About The author:

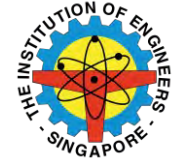
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End of Written Presentation

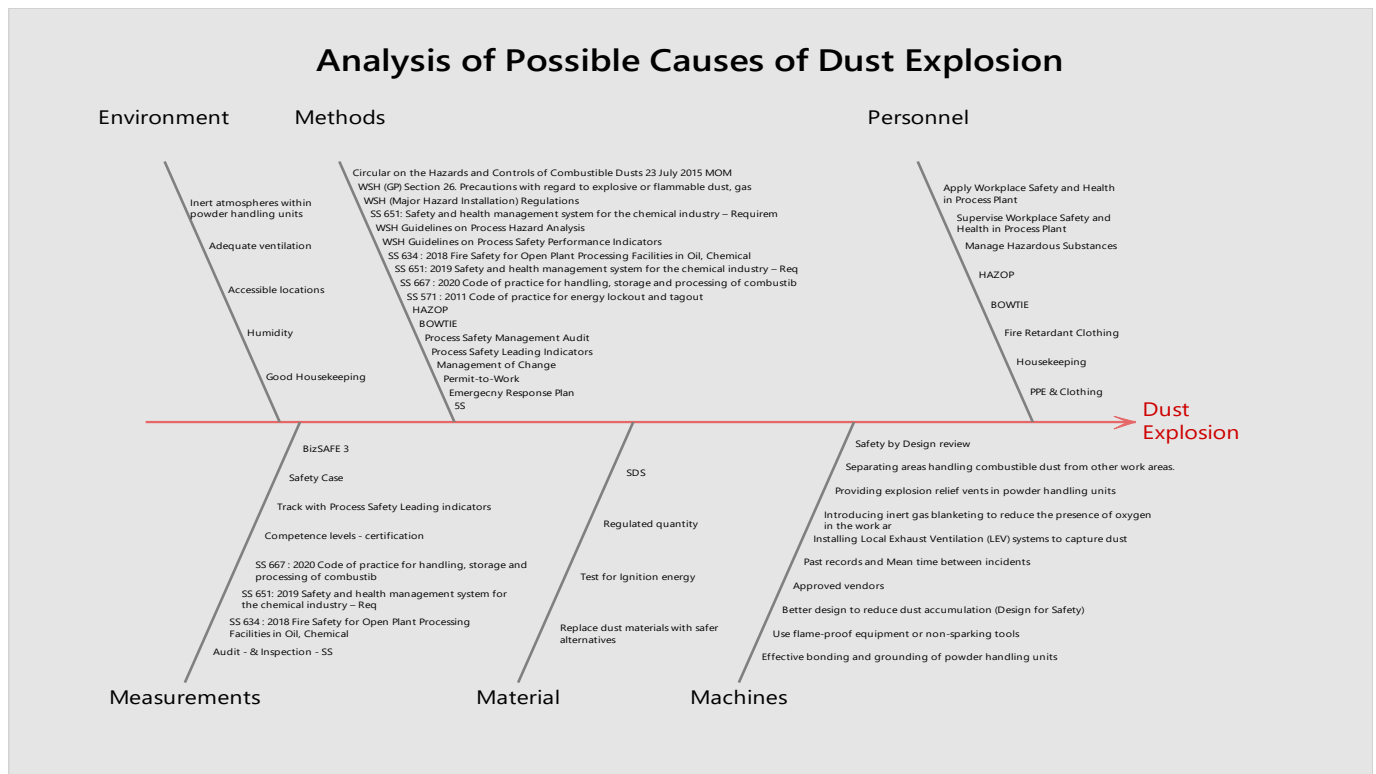
Submission to the Inquiry Committee – Explosion at 32E Tuas Avenue 11

Team formed by SISO – Singapore Institution of Safety Officers

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Willingness to appear before the Inquiry Committee	No	No	Yes	Yes	Yes

Possible Causes of the incident based on Current requirements and / or guidelines

An analysis of the incident reveals that there are adequate practices or requirements in place to ensure safe operation. The below cause and effect diagram shows a sample of identified measures available.



Despite these we have had the incident, so it is important to find a solution based on the root cause, especially for SME's

Background

- The current regulatory landscape and support structure for Chemical Process Industry is not only adequate but is possibly on par with requirements in other parts of the developed world
- While the MNC's have been able to adopt these measures and resource them according to the needs stipulated, the SME's lack the economic bandwidth to make it work for them. So, in their sincerity to adopt the measures, the solutions are possibly weighed against the minimum resources available and almost always measured against the returns
- Added to this is the multiple windows a SME needs to approach for clearance and or solutions – NEA / SCDF / BCA etc. depending on the application
- While powder handling SME's are known to be High Risk, there are other powder based SME's like Sawdust producing units that also would come under the same category.
- The local entrepreneur needs to be encouraged with a support structure that will trigger the behaviors of a Safe and Responsible industrialist or businessman. This has a bearing to the recommendations provided for the two areas of attention where comments are being sought

SISO's Recommendation 1

The MHI is a good example where NEA, SCDF and MOM come together to review and guide the Major Hazard Installations and provoke them to look in the right direction to cover all hazards and reduce risk to society at large

- ***A similar 'single window' – One stop shop concept could be adopted for SME's, where all applicable regulatory bodies and stakeholders are represented***
- ***Creation of an advisory panel, possibly within the WSH Council to guide the SME during set up and operation***
- ***All these high hazard Process SME's must have a minimum of Bizsafe 3 certification, without which they should not be allowed to start***

Focus of Attention 1

Measures to ensure the safe commissioning, operation, maintenance, and repair of industrial machines operating in a similar manner as that involved in the incident

Possible Solutions

1. Guide for SME's for Safe Operation

- Formulate a checklist for simple equipment review for safe operation of the machine
 - SME can use a simplified checklist to conduct risk assessment. It should be conducted by manufacturer or equipment owner's working team, while assisted by a competent person.
 - Safety considerations for overall evaluation should include:
 - Safety interlocking system
 - Emergency power off
 - Electrical hazard
 - Mechanical design

- Process liquid heating system
 - Exhaust ventilation system
 - Chemical hazard and Industrial hygiene
 - Exhaust ventilation
 - Fire protection system
 - Lockout tagout for hazardous energies
- Provide guidance on 'Understand your Machine'
 - 1) For this type of equipment with process heating system, list out the critical parameters:
 - Review the material used for compatibility, degrading temperature, recommended operating temperature, pressure rating if it is a closed system.
 - Review the SDS for the Chemical Heat Transfer fluid and Process chemical to identify critical information.
 - @Is the liquid for the HTF or process classified as non-combustible, flammable, or combustible liquid
 - @hazardous degrading temperature (such as flashpoint or toxic vapor emission),
 - @boiling point
 - @autoignition temperature.
 - @PPE requirement
 - @Other hazards and recommended control measures
 - 2) Review how the system function and determine the potential hazards
 - 3) Understanding the components of the machines that are critical
- Coach on 'Evaluating your control measures and risk'
 - 3) Evaluate the critical parameters and verify against the process interlock and availability of safety interlock.
 - 4) Review the process interlock, such as their position, operating characteristic and set points.
 - 5) Review the provision of safety interlock system for redundancy purpose. Include their position, operating characteristic, include set points. What happen when it trip and notification to operator.
- ❖ *Note 1: A safety interlock usually include the use of ATL (approved test lab) devices designed for safety and do not rely on software in their control circuit.*
 - ❖ *When it tripped, the power/hazards should be removed. And a warning notification provided. It will require acknowledgment which is usually the provision of a manual reset button.*
 - ❖ *Example: A "safety" overtemperature_controller meets UL873 or FM3545*
 - ❖ *Note 2: The 1st process control system will fail 1 day after many uses, the safety interlock will step-in to trip, preventing the escalation of the situation.*
 - ❖ *Note 3: During normal process condition and during a fault condition, the chemical parameters and structural integrity will not exceed their HDT for the HT fluid, raw material being process and the overall structural of the overall machine.*
- 6) Use a checklist to document and cross check if there is any recommendation that is not fulfilled

2. Guide for Commissioning

a. Step 1: "Checklist for planning stage"

This checklist to be reviewed well in advance before the arrival of the machine.

Example such as.

- i. Machine's basic information: Size, weight, facility supplies
 - ii. Layout and clearance of Machine
 - iii. Chemicals needed and their safety information
 - iv. Material of construction
 - v. Ventilation system
 - vi. Any Fire Safety provision
- b. Step 2: "Checklist prior to switching-on the machine's power", Example such as;
- i. LOTO
 - ii. Verification of safety clearance
 - iii. Facility electrical supply connection
 - iv. Safety interlock and guarding
 - v. Status of risk assessment, with only acceptable residual risks
- c. Step 3: "Checklist prior to supplying of chemical or gases", example such as;
- i. Verification of the Safety interlock and ventilation
 - ii. Chemical or gas permits and approval, SDS
 - iii. Emergency procedure and equipment
 - iv. PPE
 - v. Storage and waste handling
- d. Step 4: "Checklist before operation" example such as;
- i. Documentation for operator and maintenance tasks
 - ii. Training completion
 - iii. Corrective actions completion
 - iv. Permit / license if needed

3. Guide for Maintenance and repair

Supplier Manual, Maintenance procedure and Operator procedure.

Safety information should be recheck/included to procedures after risk assessment is completed.

- a. Have a set of Maintenance instruction (Maintenance staff) and Operator procedure (worker).
- b. Routine maintenance should include inspection/testing of the safety devices.
- c. **Process instruction** should include: The operation sequence of the process/equipment, including safety instructions. Examples;
 - i. Basic tasks, hazards, risk and preventive measures
 - ii. What action to take during a fault or emergency
 - iii. PPE requirement.
 - iv. Basic chemical safety information.
 - v. Safety alarms and operator actions needed
 - vi. Special consideration: Use of special equipment/hand tools such as explosion proof vacuum cleaner, using mopping/wetting of floor rather than sweep to reduce dust emission. (for similar case)
- d. **Maintenance procedure** (for technician) information is available and also example such as;
 - i. Energy sources for this machine and Lockout tagout procedures.
 - ii. Chemical Safety Information and safety control measures.
 - iii. Safety devices, their locations, functions, settings, testing interval, how to test. Warning notification

- iv. Fault and Troubleshooting recommendations.
- v. Action to take during an emergency such as fire, explosion, chemical spill etc.
- vi. Equipment Inspection schedules and forms used
- vii. Basic machine information. Size of machine, weight, facility supplies

4. Guide for Other Considerations

a. Management of Change

- i. Review the risk assessment and evaluate the new change.
- ii. The risk assessment team to re-assess the hazards (new or existing) to determine the risk and effectiveness of the existing control measures.
- iii. Any retraining needed and documents needs for update.

b. Vendor/supplier:

Evaluate the quality and safety of the machine, certified to an applicable safety standard or guidelines. Some certificates are self-certified while others are certified by a reputable 3rd party laboratory. Retrofitting a machine will need time, cost and additional work.

Accredited / Approved Test Laboratories: 3rd party companies that conduct testing of components or certification of a product according to safety standards and are recognized by authorities. Some examples, such as UL, TUV and CSA

IEC organization has certification bodies and have authorized approved test laboratories in many countries. They issued certificates or test reports that indicate their electrical and electronic components meeting IEC standards.

CE Mark: EU requirement for manufacturer to declare and mark their product which meets the European safety requirements/directives.

Notified body: An organization/laboratory approved by the EU to conduct assessment for their components according the EU requirements. A component with notified body certification will be useful in your machine safety assessment.

c. Training

- i. Operator, and Technician training should include based on the topic in Process instruction
- ii. Consideration for renewal training

d. Risk assessor:

- i. Consider online training availability for required skill set.
- ii. Specialized risk assessment for similar type of equipment safety to be considered.
- iii. Existing consultants and 3rd parties engineering laboratories may serve as guide or lead assessor, if needed.
- iv. They should possess competency in machine design standards and maintenance.

The above are some recommendations and although may seem exhaustive, will need more time to develop.

SISO's Recommendation 2

Develop a guide for SME's, that will include elements of PSM, SS 651 etc., such as Mechanical Integrity, Management of Change, PSSR (Pre-Start-up Safety Review),

Vendor Management etc. This will also include competence requirements for personnel operating such equipment and facilities.

Focus of Attention 2

Measures to ensure the safe supply, storage, and handling of combustible dust or powders at workplace settings like that involved in the incident

Possible Solutions

1. Guide for SME's on
 - a. Procurement of material
 - i. Approved and licensed suppliers / vendors
 - ii. Provision of SDS by approved vendor
 - b. Test centers – Powders or chemical reactions based on process
 - i. Approved testing centers / Laboratories
 - c. Design needs of storage and handling
 - i. Conveyance / transportation of dust / powders
 - ii. Ventilation requirements
 - iii. Safety Emergency features
 - iv. Emergency response plan & equipment
 - d. Training and Competency
 - i. Training matrix for Managers / Supervisors / General Workers / Admin etc
 - ii. Approved Training Centers
 - e. Disposal requirements
 - i. NEA regulations and guidelines
 - ii. Spill kits requirement and response
 - f. Housekeeping
 - i. Industry standard guideline and examples
 - ii. Inspections and audits
 - g. Area of classification
 - i. SCDF requirements / approved certification
 - h. Industrial Hygiene
 - i. Exposure to raw material and products
 - ii. Monitoring of health etc
 - i. Uniform and PPE
 - i. Approved standards
 - ii. Maintenance guidelines
 - iii. Vendor support
 - j. Leading and Lagging Indicators
 - i. Investigation of events
 - ii. Closure of actions
2. Enhance the Technical capability of SME's through
 - a. Blend the relevant Safety Case approach into BizSAFE for High hazard Process SME's
 - b. Relevant Dust handling training with certification of competence for Operators, Supervisors and Managers

3. Explore the 'safety mark accreditation' for dust / powder handling related equipment and machinery
4. Initiate a cultural program to influence the culture on safe handling of powders / dust through
 - a. Support from SCIC using the 'Responsible Care' (RC) approach
 - b. Have a RC mentor for these industries
 - c. Create a community of practice amongst this group

The above are some recommendations and although may seem exhaustive, will need more time to develop.

SISO's Recommendation 3

Linked to recommendation 1, we propose the creation of a Pre-Start-up and on-going list of guidelines and checks aligned with the above points that can be used by SME's to follow or seek guidance from an advisory panel to continually run their industry safely and productively

Reference Documents

- PSM Code – OSHA 3132 2000
- PSPI Guidelines – WSHC
- Responsible Care – ICCA / SCIC
- SS 651
- BizSAFE – MOM
- SEMI S3 - Safety Guideline for Process Liquid Heating Systems
- SEMI S2 Safety Guideline, Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

Date : 10 November 2021

Inquiry Committee Secretariat

Ms Audrina Chua

Occupational Safety and Health Division
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Ministry of Manpower Services Centre
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**WRITTEN REPRESENTATION TO THE INQUIRY COMMITTEE FOR THE FATAL
ACCIDENT AT STARS ENGRG PTE LTD ON 24 FEBRUARY 2021**

In response to the Inquiry Committee's invitation, SCDF has prepared a written representation with a focus on the measures to ensure the safe supply, storage and handling of combustible dust or powders at workplace settings similar to that involved in the abovementioned accident.

2. SCDF's investigation findings showed that the explosion that occurred in the premises after the initial fire in the machine was likely caused by a dust explosion of potato starch powder, a form of combustible powder. The accident has demonstrated the risks posed by these combustible powders. SCDF is of the view that regulatory controls over combustible powders can be tightened.

3. In the following paragraphs, SCDF has set out our current regulatory regime for Petroleum and Flammable Materials (P&FM), which includes four combustible metal powders, under the Fire Safety Act (FSA). We have also explained the limitations of relying on the FSA levers to address the hazards posed by the industrial use of combustible powders, and elaborated on the proposed alternative measures to enable better oversight of the presence and use of combustible powders in workplaces by MOM.

Background on SCDF's Regulatory Regime for Petroleum and Flammable Materials

4. SCDF regulates substances that pose a flammability hazard through a licensing regime under Part IV of the FSA, which relates to the control of P&FM.

5. SCDF determines the chemicals to be regulated under the P&FM licensing regime based on established hazard classification systems such as the UN Hazard Classification and the Globally Harmonised System (GHS) which are widely adopted globally, taking into account whether the substances are used in Singapore for industrial purposes.

6. The full list of regulated chemicals is found in the Fourth Schedule to the Fire Safety (P&FM) Regulations. Of the regulated chemicals, four are combustible metal powders (i.e. aluminium, iron carbonyl, magnesium, and zinc), which are also classified under the UN

Hazard Classification system as flammable solids. Although there are many other combustible powders used for various purposes, we understand that most of them, such as milk powder, sugar, flour and epoxy resin, are not classified as flammable solids under international standards. Therefore, SCDF does not regulate them as such.

Limitations of SCDF's Regulatory Controls in Addressing Combustible Dust Hazards

7. While it is possible to amend the list of chemicals in the Fire Safety (P&FM) Regulations to include other combustible powders, and SCDF is prepared to consider this if necessary, SCDF's view is that doing so may not significantly reduce the risk of dust explosion for the following reasons:

- a. **Combustible powders are generally in a steady state condition during storage, with a low risk of dust explosion.** The risk of a dust explosion arises when the combustible powders are processed, such as when there is an accumulation of the powder in the air, and there are heat sources present within a confined space where the processing takes place.
- b. **The scope of SCDF's regulatory regime focuses on the storage of substances, and not industrial processes involving these substances.** In this regard, bringing combustible powders under the P&FM licensing regime would not address the risk factors for dust explosions, which typically occur during processing and not in storage. Furthermore, we understand that process-related dust explosion risks at workplaces are currently addressed through safety requirements imposed under MOM's Workplace Safety and Health (General Provisions) Regulations.

Alternative Measures for Better Oversight

Reflecting fire safety provisions relating to combustible powders in plans submission

8. Within the existing regime, SCDF has already taken steps to enhance the fire safety requirements for premises that store, handle and process combustible powders under SCDF's regulatory purview. SCDF issued a Circular on 1 Jun 2021 to inform the industry of the additional fire safety requirements under the recently launched SS 667 (Code of practice for handling, storage and processing of combustible dust) that will apply to all new buildings and buildings undergoing fire safety works that store flammable powders. These requirements include the installation of additional fire safety cabinets if the quantity of the combustible powders exceed the specified Maximum Allowable Quantity (MAQ) and MAQ of the powders stored in bulk per fire compartment.

Sharing of Information with MOM

9. Currently, building owners who intend to store P&FM (including the four combustible metal powders) on their premises are required to declare their intent and cater the necessary

fire safety measures associated with the storage of these P&FM when preparing their building plans to be submitted to SCDF.

10. SCDF is open to sharing available information on the regulated combustible metal powders with MOM, for regulatory purposes, subject to the Government's Instruction Manuals on the sharing and use of data within the Government. Such information includes building plans and the quantity of P&FM stored on-site.

Relying on Workplace Safety and Health audit regime

11. We understand that MOM currently has in place a workplace safety and health management system and audit regime for *selected workplaces* (e.g., shipyards, factories engaged in manufacturing of petroleum/petrochemical products). Under this regime, workplaces must appoint an independent auditor to regularly audit their safety and health management systems, including the safe use of combustible powders and proper housekeeping. It may therefore be useful to consider if such a regime could be *extended to all workplaces* that handle combustible powders, so that such workplaces may systematically identify and rectify weaknesses in their safety and health management system

Representatives from SCDF for hearings

12. The following 2 officers will represent SCDF during the hearings to provide further clarifications where necessary:

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This submission highlights how workers are educated on workplace risks, in particular, those related to handling machinery and combustible dust. It also provides recommendations related to WSH training, to prevent the recurrence of accidents like the explosion and fire at Stars Engineering Pte Ltd at 32E Tuas Avenue 11 on 24 February 2021.

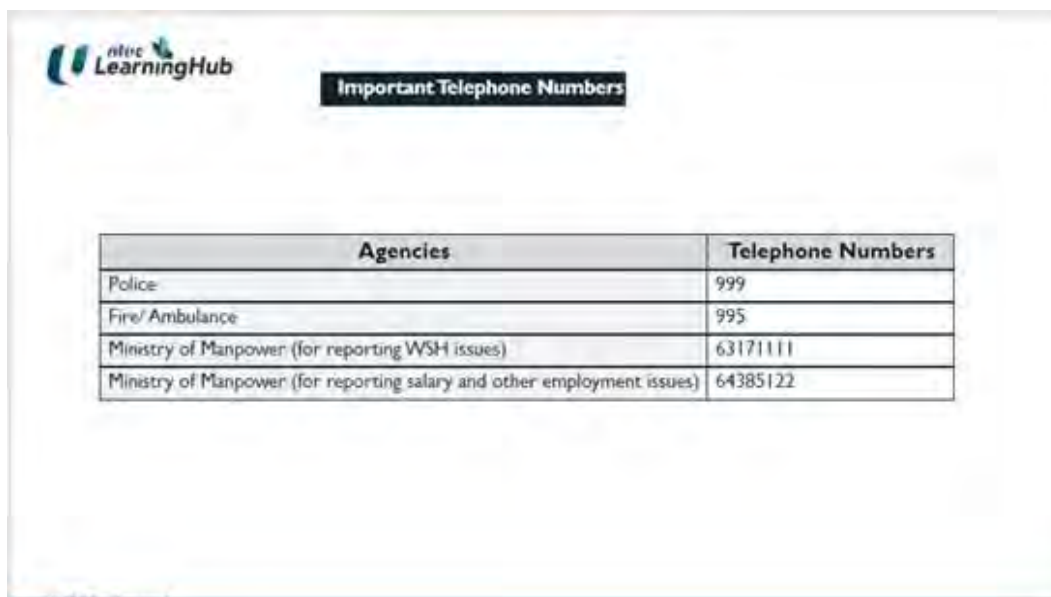
1. About the Workplace Safety and Health Council (WSHC)

WSHC is a statutory body under the Ministry of Manpower, guided by a Council represented by industry, union and government leaders. Its main roles are to:

- a. **Educate employers and employees** about how to improve workplace safety and health, through industry events, promotional material and resources.
- b. **Build industry capability** in managing WSH, through setting the national WSH training framework and administering capability development programmes like bizSAFE.
- c. **Set standards** for acceptable WSH practices, through the formulation of WSH guidelines and Approved Codes of Practice.

2. Workers' Training and Competency

- a. Workers in relatively high-risk environments such as construction worksites, shipyards, and certain factories, are required under the Factories (Safety Training Courses) Order and the WSH (Shipbuilding and Ship-repairing) Regulations, to attend a safety orientation course (SOC) or safety training course for their specific role, before working in these workplaces and roles. These mandatory WSH training courses teach workers to identify hazards, and safe practices that reduce risk for themselves and their colleagues. They are conducted in the migrant workers' native languages. The SOC also covers a worker's WSH-related legal rights and responsibilities. Workers are encouraged to report or to whistle blow any unsafe work conditions, unsafe acts, unsafe workplace hazards, work-related incidents, or accidents or near misses at the workplace. For example, they are taught to contact MOM at 6317 1111 to report WSH issues such as "red flags" that would compromise their safety (see sample below from NTUC Learning Hub's SOC material). The workers at Stars Engineering had gone through their SOC.



Agencies	Telephone Numbers
Police	999
Fire/ Ambulance	995
Ministry of Manpower (for reporting WSH issues)	63171111
Ministry of Manpower (for reporting salary and other employment issues)	64385122

- b. As a condition for work pass renewal, all work permit holders in higher-risk industries are required to either i) pass the SOC re-certification test every 2 years (if they have worked in the sector for 6 years or less) or every 4 years (if they have worked in the sector for more than 6 years); or ii) have passed a safety supervisor course.
- c. Besides the SOC and the supervisory training courses, non-Malaysian Work Permit Holders in the construction, manufacturing, marine, and process industries, such as those at Stars Engineering, are also required to attend a Settling-In Programme (SIP) within 2 weeks of their arrival in Singapore, to learn about their employment rights. The SIP reinforces the call to report unsafe work conditions. Attendees are encouraged to report WSH issues to the Migrant Workers Centre if they are more comfortable with approaching an NGO instead of the regulatory authorities.
- d. To complement the mandatory training programmes mentioned above, under s12(3)(e) of the WSH Act, employers are to ensure that their workers are given adequate instruction, information, training, and supervision to carry out their work safely. These include sending them for trade and professional WSH training relevant their job role. In 2019 (pre-covid), over 300,000 workers attended WSH training with accredited training providers, ranging from the SOC, to different trade and professional courses. See Annex for a list of accredited WSH training courses. Employers' WSH training obligations also include providing instructions and in-house training specific to the workers' job functions, including how to operate and maintain machinery used at the worksite safely. Workers should also be made aware of the safe work procedures and safety rules implemented at the workplaces, to properly use and don the PPE provided to them, and not to tamper or misuse any machinery and or equipment.

3. **General Safety on the Use of Machinery and the Handling of Combustible Dust**

To assist the Employer to conduct Risk Assessments for their work processes and environment, MOM and the WSHC have published guidelines to address various hazards. These include good WSH practices and suggested control measures to ensure the safe use of machinery and to prevent fires, such as the following:

- a. **WSH Guidelines on Flammable Materials** – These guidelines provide risk control measures for work with flammable materials, including highly flammable liquids like petrol and less apparent fuel sources, such as combustible dust.
- b. **WSH Guidelines on Management of Hazardous Chemicals Programme** – These guidelines address the key elements in managing hazardous chemicals during production, storage, transportation, usage, handling, and disposal.
- c. **WSH Guidelines on Process Hazard Analysis** – These guidelines introduces enterprises to Process Hazard Analysis (PHA) methodologies to help them identify process hazards as early as possible and to put in place measures to control risk.
- d. **MOM's Circular on the Hazards and Controls of Combustible Dusts** – The circular highlights how dust combustions can occur and introduces some control measures.

WSHC engages industry associations and unions to help in disseminating WSH guidelines and other information to their members. We also use our WSH Bulletin to inform our 75,000 subscribers. For selected critical updates, MOM will also issue circulars to inform all relevant employers.

4. **Recommendations**

While workers are required to undergo structured training on safe work procedures and educated on channels to report WSH issues at the start of the work in Singapore, these lessons might not be reinforced throughout their career, especially if their employer does not emphasise adherence to safe work procedures or does not have a comprehensive in-house training regime. To sustain WSH knowledge among workers, we suggest that workers in higher-risk industries be required to also attend refresher WSH training at regular milestones throughout their career. Modular refresher training courses will be better able to suit the different job roles that each worker may be deployed to perform. They can also be updated with the latest WSH knowledge based on recent accidents and evolving legislative requirements (such as if stricter controls on use of combustible dust and machinery modifications/repairs are put into place).

For all 600,000 Work Permit Holders across all industries, WSH also intends to supplement their employer-sponsored training by sending them continuous WSH education in their native language via the FWMOMCare app. Avenues for whistleblowing and highlighting of “red flags” can also be reinforced via this channel.

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**MR CHRISTOPHER KOH
GENERAL MANAGER,
WORKPLACE SAFETY AND HEALTH COUNCIL**

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LIST OF ACCREDITED WSH TRAINING COURSES BY INDUSTRY RELEVANCE

	WSH COURSE	INDUSTRY
1	Perform Design for Safety Professional Duties	Construction/Facilities Management
2	Perform Industrial Audiometric Screening	ALL
3	Supervise Manufacturing Work for WSH	Manufacturing
4	Apply Workplace Safety and Health in Shipyard (Marine Safety Orientation Course)	Marine
5	Supervise Marine Work for WSH	Marine
6	Manage Workplace Safety and Health in Shipbuilding and Ship Repair	Marine
7	Assess Shipyard Safety for Hot-Work Certification	Marine
8	Operate Explosive Powered Tools	ALL
9	Perform Metal Scaffold Erection	Construction/Facilities Management
10	Supervise Metal Scaffold Erection	Construction/Facilities Management
11	Perform Rigging of Suspended Scaffold	Construction/Marine /Facilities Management
12	Supervise Suspended Scaffold	Construction/Marine/Facilities Management
13	Erect Metal Scaffold in Marine Industry	Marine
14	Supervise Metal Scaffold in Marine Industry	Marine
15	Perform Manhole Safety Assessment	Construction/Facilities Management
16	Perform Work-at-Height	ALL
17	Manage Work-At-Height	ALL
18	Perform Man-lock Attendant Duties for Compressed Air Work	Construction
19	Perform Medical-Lock Attendant Duties for Compressed Air Work	Construction
20	Manage Workplace Safety and Health in Construction Sites	Construction
21	Supervise Workplace Safety and Health for Formwork Construction	Construction
22	Perform Formwork Activities	Construction

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	WSH COURSE	INDUSTRY
23	Apply Workplace Safety and Health in Logistics and Transportation (Logistics and Transportation Safety Orientation Course)	Logistics and Transport
24	Apply Workplace Safety and Health in Construction Sites (Construction Safety Orientation Course)	Construction
25	Supervise Construction Work for Workplace Safety and Health	Construction
26	Apply Workplace Safety and Health in Metal Work (Metalworking Safety Orientation Course)	Metalworking
27	Supervise Tunnelling Work for Workplace Safety & Health	Construction
28	Apply Workplace Safety and Health in Process Plant (Process Safety Orientation Course)	Process
29	Supervise Workplace Safety and Health in Process Plant	Process
30	Develop a Risk Management Implementation plan (bizSAFE Level 2)	ALL
31	Develop a Workplace Safety and Health Management System Implementation Plan (bizSAFE Level 4)	ALL
32	Certificate in Workplace Safety & Health (Level A)	ALL
33	Advanced Certificate in Workplace Safety & Health (Level B)	Construction /Marine/Manufacturing/Process
34	Specialist Diploma in Workplace Safety & Health (Level C)	ALL
35	Graduate Certificate in Workplace Safety & Health (Level D)	ALL
36	Operate Lorry Crane	ALL
37	Operate Boom Lift	Construction, Marine, Manufacturing, Facilities Management
38	Operate Scissor Lift	Construction, Marine, Manufacturing, Facilities Management
39	Operate Vertical Personnel Platform	Construction, Marine, Manufacturing, Facilities Management
40	Operate Forklift	ALL
41	Control Noise and Vibration	ALL
42	Monitor Noise and Vibration	ALL
43	Supervise Safe Lifting Operations	ALL
44	Perform Rigger & Signalman Tasks	Construction and Marine
45	Perform Work in Confined Space Operation	Construction/Marine/Facilities Management/Process
46	Supervise Work in Confined Space Operation	Construction/Marine/Facilities Management/Process

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	WSH COURSE	INDUSTRY
47	Assess Confined Space for Safe Entry and Work	Construction/Marine/ Facilities Management/Process
48	Workshop to Enhance the Safety of Crane Operators	Construction and Marine
49	Commercial Diving (CSCUBA) for Divers	Marine
50	Commercial Diving (CSCUBA) for Supervisors	Marine
51	Commercial Diving (SSDE) for Divers	Marine
52	Commercial Diving (SSDE) for Supervisors	Marine
53	Occupational First Aid course	ALL
54	SSIC (Hot Works)	Marine
55	SSIC (Painter Trade)	Marine
56	SOC Tunnelling for workers	Construction



WRITTEN SUBMISSION (PART 1 – MAIN REPORT)

*Inquiry Committee into Incident involving Fire and
Explosion at Stars Engrg Pte Ltd on 24 February 2021*

Includes recommendation themes for:

Theme A: Regulatory Regime on Combustible Dust or Powders
Theme B: Regulatory Regime on Safe Use of Industrial Machinery

Prepared by OSHD

1 | Page

Contents

1.	Introduction	3
2.	Background on OSHD	4
	2.1 About OSHD	4
	2.2 OSHD’s efforts in the aftermath of the accident at Stars.....	6
3.	Theme A: Regulatory Regime on Combustible Dust or Powders	7
	3.1 Introduction	7
	3.2 Combustible Dust	7
	3.3 Benchmarking Singapore’s safety regulatory regime for combustible dust against other countries.....	9
	3.4 Current control on combustible dust in Singapore.....	10
	3.5 Recommendations	13
	3.6 Recommendation (1) – Import and Supply: Requiring Suppliers to Label Combustible Dust Hazards Before Selling or Redistributing	13
	3.7 Recommendation (2) – Bulk Storage: Requiring Companies that Handle a Prescribed Amount of Specified Combustible Powders to register or notify the Authorities	14
	3.8 Recommendation (3) – Usage: Impose duties on Occupiers to alert Building Owners and Landlords on use of Combustible Powders as part of their Operations	15
4	Theme B: Regulatory Regime on Safe Use of Industrial Machinery	16
	4.1 Introduction	16
	4.2 The Kneader Machine.....	16
	4.3 Benchmarking of Singapore’s regulatory regimes on safe use of machinery against other countries.....	16
	4.4 Current regulatory regimes on safe use of industrial machinery in Singapore	17
	4.5 Key considerations on adequacy of regulatory regime.....	20
	4.6 Recommendations	22
	4.7 Recommendation (1) – Encourage buyers of industrial equipment to certify the equipment they purchase to Singapore Standard SS 537-1.....	22
	4.8 Recommendation (2) – Expand the Fifth Schedule of the WSHA to include more industrial equipment.....	22
5	Conclusion	24

1. Introduction

- 1.1 On 24 February 2021, workers at Stars Engrg Pte Ltd (“**Stars**”) which was located at 32E Tuas Ave 11, were operating an industrial kneader machine when an explosion and fire occurred. It is believed that the explosion and fire occurred at the kneader machine following a physical rupture of the kneader machine’s oil jacket due to internal overpressure and that the initial explosion and fire was followed by secondary flash fires involving combustible dust powders (i.e. potato starch powders).
- 1.2 The Occupational Safety and Health Division (“**OSHD**”) of the Ministry of Manpower (“**MOM**”) is concerned to ensure the prevention of future similar accidents. In this regard, this report on MOM’s views as regards to possible recommendations is submitted for the Inquiry Committee’s consideration.
- 1.3 This report will first provide some general background on the work done by OSHD, including OSHD’s efforts in the aftermath of the accident. The report will then discuss the following two themes which are relevant to the accident and propose relevant recommendations within each theme:

Theme A: Regulatory Regime on Combustible Dust or Powders

Theme B: Regulatory Regime on Safe Use of Industrial Machinery

2. Background on OSHD

2.1 About OSHD

2.1.1. OSHD is a division under the Ministry of Manpower (MOM) that promotes Occupational Safety and Health at the national level. OSHD works with employers, employees and all other stakeholders to identify, assess and manage Workplace Safety and Health risks so as to eliminate death, injury and ill health at work.

Our Vision

2.1.2. Our vision is a healthy workforce in safe workplaces and a country renowned for best practices in workplace safety and health (“**WSH**”).

The WSH 2028 National Strategy

2.1.3. MOM established the WSH 2028 Tripartite Strategies Committee in 2018 comprising of representatives from government and industry stakeholders to recommend a set of 10-year WSH strategies to realise the vision of having “A Healthy Workforce in Safe Workplaces and A Country Renowned for Best Practices in Workplace Safety and Health”. As part of the strategy, MOM aims to reduce Singapore’s fatal injury rate to below 1.0 per 100,000 workers on a sustained basis by the year 2028. Only four countries in the Organisation for Economic Co-operation and Development (OECD) have achieved this. The WSH 2028 was launched in 2019.

2.1.4. The strategic outcomes to track progress in attaining the WSH 2028 are as follows:

4 Strategic Outcomes

- i) Sustained Reduction in Workplace Injury Rates;
- ii) Minimise Hazards that Lead to Occupational Disease;
- iii) Promotion of Good Workforce Health; and
- iv) Pervasive Adoption of the Vision Zero Culture.

3 Strategies

- i) Strengthen WSH Ownership;
- ii) Enhance Focus on Workplace Health; and
- iii) Promote Technology-Enabled WSH.

OSHD Function

- 2.1.5. OSHD main regulatory function is in ensuring compliance with the Workplace Safety and Health Act (“**WSHA**”) as well as the Work Injury Compensation Act (“**WICA**”). The WSHA provides the regulatory framework that focuses on reducing WSH risks at source and requiring stakeholders to eliminate or minimise potential risks at workplaces. The WICA is a legislative instrument that ensures the right of an employee to claim compensation in the event of a work-related injury, death or occupational disease. OSHD works closely with the WSH Council and its tripartite partners to strengthen WSH culture and practices and to prevent injury and ill-health at work.
- 2.1.6. On WSHA, OSHD is tasked with ensuring compliance with the WSHA and its subsidiary legislation. This task is undertaken by the Operation departments namely, Occupational Safety and Health Inspectorate, the Occupational Safety and Health Specialists Department and the Major Hazards Department. The main function is to ensure that WSH standards are adhered to. OSHD does this by:
- a) Expanding the reach and depth of enforcement through strategic inspections;
 - b) Performing surveillance on workplaces; and
 - c) Providing targeted attention to high-risk workplaces.
- 2.1.7. The WSHA covers all workplaces in Singapore. But, having regard to the need to use limited resources efficiently, OSHD takes a targeted and risk-based approach to its work. Accordingly, OSHD targets traditional areas of concern in the construction, marine and manufacturing industries, as these industries tend to see a higher number of fatal accidents based on past WSH statistics. In 2020, for example, the top two causes of workplace fatalities were falls from height and vehicular-related incidents, similar to previous years. Together, they contributed to 40% of all workplace fatalities in 2020.
- 2.1.8. OSHD conducts targeted inspections and sustained enforcement actions based on analysis of industry trends and WSH statistics so that the greatest impact on improving WSH performance can be delivered. For example, following the spate of fatal accidents in first half of 2021, OSHD stepped-up its enforcement operations to include workplaces with combustible dust hazards and at other high-risk sectors such as manufacturing and construction, with a focus on machinery safety. More than 1000 workplaces were inspected under these operations.
- 2.1.9. In addition to its efforts on the traditional high-risk sectors, OSHD keeps its pulse close to the ground on new and emerging risks such as in the areas of workplace health,

mental health and prevention of infectious diseases at workplaces. OSHD works closely with its tripartite partners, industry associations and professional bodies to develop guidelines and programmes to raise awareness on such risks.

2.2 OSHD's efforts in the aftermath of the accident at Stars

2.2.1 Following the accident at Stars, OSHD identified combustible dust hazard as one of the key issues involved in the accident. As a follow-up, OSHD conducted a special enforcement operation codenamed "Operation Bullfinch 2" in March 2021 to assess the adequacy of safety measures to address risks associated with dust explosion hazards in the manufacturing industry. As part of the operations, OSHD inspected approximately 500 companies that potentially deal with combustible dust. These included manufacturing companies that manufacture, process or handle combustible powders such as metallic, chemical or organic (such as food) powders and products. In particular, OSHD's enforcement focused on SMEs that were unlikely to have the same level of awareness of the risks of combustible dust hazard as compared to the bigger manufacturing companies.

2.2.2 The results of the Operation revealed that most companies inspected used or generated small quantities of combustible dust which had low explosion risk. Notwithstanding, awareness of combustible dust hazards in these companies were observed to be low, as evident from the lack of identification of combustible dust hazards in their risk assessment. For larger companies that have industrial processes involving combustible dust, these companies were generally observed to have identified combustible dust hazards in their risk assessments and have the necessary control measures put in place.

3. Theme A: Regulatory Regime on Combustible Dust or Powders

3.1 Introduction

Different agencies regulate combustible dust or powders (hereafter referred to as “combustible dust”) under their respective legislative ambit. This section provides an overview on how combustible dust is controlled in Singapore and how our safety regulatory regime on combustible dust compares with other developed countries. It will end with recommendations on combustible dust control based on the different stages along its life cycle.

3.2 Combustible Dust

3.2.1 Combustible dusts are fine particles that are liable to catch fire or explode when dispersed in air or other oxidising media under certain conditions. There are many types of combustible dusts and they can be grouped into 4 categories: Metals, Chemicals, Plastics and Organic Matter. The potato starch used by Stars falls under the organic matter group.

3.2.2 Most of these combustible dusts are not inherently dangerous (e.g. sugar or flour). However, a flash fire can occur when four elements (Fuel, Oxygen, Ignition & Dispersion) are present. When a fifth element (Confinement) is also present, it can lead to a combustible dust explosion (please see [Figure 1](#)).

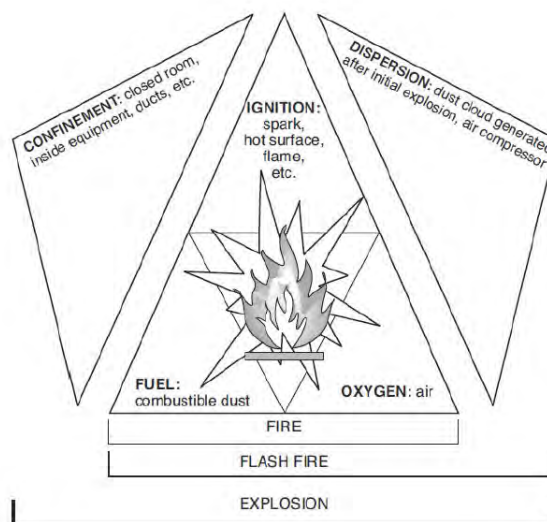


Figure 1: Elements required for fires, flash fires and explosions
(Source: NFPA 652 2019 Figure A.5.2)

3.2.3 Different dusts of the same material can have different ignitability and explosibility characteristics, depending on its physical characteristics such as particle size, shape, and moisture content. These physical characteristics can change during manufacturing, use or while the material is being processed.

Methodology to Determine Risk Level

3.2.4 International practice uses K_{st} value (dust deflagration index) to measure the relative explosion severity compared to other dusts. In general, the larger the K_{st} value of the substance, the more severe the explosion (See [Table 1](#)). However, the severity of the explosion is also influenced by other factors such as quantity of combustible dust stored or used, and the work process or activity involved. For instance, when combustible dust is stored within the packages in a warehouse, it is considered as low risk as there is low likelihood for generation of dust cloud. On the contrary, if the workplace has processes involving open charging of combustible powders into the system, the likelihood of dust cloud generation in the workplace is increased and the risk of combustible dust explosion will be much higher.

Table 1: Examples of K_{st} values for different types of dusts and risk level

Dust explosion class*	K_{st} (bar.m/s) ^a	Characteristic ^a	Typical materials ^b	Risk Level
St 0	0	No explosion	Silica	No Risk
St 1	$0 < K_{st} \leq 200$	Weak explosion	Powdered milk, charcoal, sulphur, sugar and zinc	Lower Risk
St 2	$200 < K_{st} \leq 300$	Strong explosion	Cellulose, wood flour, and poly methyl acrylate	Higher Risk
St 3	$K_{st} > 300$	Very strong explosion	Anthraquinone, aluminum and magnesium	
*The actual class is sample specific and will depend on specific characteristics of the sample such as particle size or moisture level.				
^a OSHA CPL 03-00-008 – Combustible dust national emphasis program				
^b NFPA 68, Standard on explosion prevention by deflagration venting				

3.2.5 The American National Fire Protection Association (NFPA) is one of the internationally recognised authorities on fire protection. The NFPA standard 652 provides a listing of the K_{st} values of over 100 materials. There is also a more comprehensive database by the Institute for Occupational Safety and Health of the German Social Accident Insurance (GESTIS-DUST-EX) which has combustion and explosion characteristics of close to 7000 materials. Under this listing, there were several K_{st} values listed for potato starch, which was the combustible dust used by Stars. The highest K_{st} value for potato starch provided in the database was 116 (Under Class St 1).

3.3 Benchmarking Singapore’s safety regulatory regime for combustible dust against other countries

3.3.1. A literature scan on the regulatory requirements on combustible dust was conducted for 3 developed countries that have established laws and standards – US, UK and Australia. Singapore’s and Australia’s laws are modelled after UK’s outcome-based Health and Safety at Work Act which is supplemented with more prescriptive subsidiary legislations, whereas US adopts a more prescriptive legislative approach.

3.3.2. [Table 2](#) summarises the similarities and differences between Singapore and the 3 countries’ regimes in the control of combustible dust hazards. While our regulatory regime is comparable to the 3 countries in most of the areas compared, the US’s and UK’s regime of identification and communication of combustible dust hazards is more comprehensive.

Table 2: Summary of Singapore's regulatory regime against other developed countries

Areas	Findings
Duties of Employer	<ul style="list-style-type: none"> All 3 countries impose a general duty on employers to ensure the safety and health of employees at work. Singapore’s WSHA similarly imposes such a general duty.
Duties of Manufacturer, Supplier and Importer to communicate hazards	<ul style="list-style-type: none"> UK and US require suppliers, manufacturers or importers of combustible dust to provide information and warn of potential explosion hazard to users. Australia’s and Singapore’s requirements for suppliers and manufacturers are scoped to a narrower list of hazardous substances. Both countries also do not cover the importers. <ul style="list-style-type: none"> Both countries adopt the labelling requirement in accordance with the Globally Harmonised System (GHS) which does not include combustible dust.

	<ul style="list-style-type: none"> ○ Singapore’s requirements are tied to the Fifth Schedule Part II of the WSHA which prescribed a list of hazardous substances, which does not include combustible dust.
Control Measures <ul style="list-style-type: none"> • Hazardous Area • Local exhaust ventilation • Housekeeping • Ignition control • Explosion relief and venting 	<ul style="list-style-type: none"> • All 3 countries have prescriptive requirements to control combustible dust hazard at the workplace. • In Singapore, we also have similar prescriptive precautions to take for explosive or flammable dusts, gases, vapours or substances. This is provided under Reg 26 of the WSH (General Provisions) Regulations

The details of the legislation for the respective countries are appended in [Annex A](#).

3.4 Current control on combustible dust in Singapore

3.4.1. Due to the wide variety of combustible dusts, there is no single authority regulating combustible dust. Instead, different agencies regulate different materials or substances (some of which are combustible dusts) under their respective legislations. [Table 3](#) summarises the various agencies’ involvement. The details of the Regulations for respective agencies are compiled in [Annex B](#).

Table 3: Regulatory agencies' roles based on the life cycle stages of combustible powders

Agencies	Import	Distribution	Storage	Use	Disposal
Singapore Customs (SC)	Import declarations are submitted through TradeNet platform				
Singapore Food Agency (SFA)	Trader needs to be registered to import processed food. Labelling requirements for food safety are imposed. <i>[Examples of processed food include potato starch, flour, etc., which are combustible powders]</i>				

Agencies	Import	Distribution	Storage	Use	Disposal
			License to manufacture and process of animal feed. <i>[Animal feed is an organic matter which are combustible powders]</i>		
Singapore Civil Defence Force (SCDF)	Petroleum and Flammable Materials (P&FM) license is required for import, storage and use of P&FM at any premises. <i>[List of P&FM Include metal powders such as aluminum, magnesium, zinc and iron carbonyl which are combustible powders]</i>				
			The building plan approval for fire safety works will also apply to premises that store and use flammable substances.		
Ministry of Manpower (MOM)			Protection of persons at work under WSHA and its subsidiary legislations. Precautions and measures to be taken at workplaces with regards to explosive or flammable dust, gas, vapour or substance.		
National Environment Agency (NEA)			The development control and building plan approvals may apply to premises that store and use combustible dust to ensure compliance with environmental health and pollution control requirements.	License Toxic Industrial Waste (TIW) collectors to ensure proper disposal of TIW. <i>[TIW include polyvinylchloride waste which is combustible dust]</i>	

MOM's Circular on the Hazards and Controls of Combustible Dusts in 2015

3.4.2. Arising from a 2013 combustible dust fire where 2 workers suffered burn injuries, MOM conducted a proactive operation to assess and engage the process industry on combustible dust. Following the operations, MOM issued a circular to industry in 2015 to raise awareness of the hazards and risk control measures relating to combustible dusts in workplaces. A non-exhaustive list of combustible dust examples was included in the circular (refer to [Table 4](#)).

Table 4: Examples of combustible dusts listed in MOM 2015 Circular

Category	Examples
Metals	Aluminium, Bronze, Magnesium, Zinc, Iron Carbonyl.
Chemicals	Adipic Acid, Ascorbic Acid, Sodium Ascorbate, Calcium Acetate, Calcium Stearate, Sodium Stearate, Lead Stearate, Dextrin, Lactose, Methylcellulose, Paraformaldehyde, Sulphur.
Plastics	Polymers e.g. Polymethylmethacrylate, Polyacrylamide, Polyacrylonitrile, Polyethylene, Polyvinylchloride, Resins, Melamine.
Organic Matter	Sugars, Corn Starch, Flour, Charcoal, Coal, Peat, Soot, Cellulose Pulp, Tobacco, Wood Dust

3.4.3. Companies were advised to implement proper control measures such as dust control, ignition control, explosive relief and venting, training and awareness as well as the use of personal protective equipment to mitigate the risk and prevent combustible dust explosions.

Development of New Singapore Standard on Combustible Dust

3.4.4. A work group was also set up in 2017 under the Enterprise Singapore (ESG) to develop a Singapore Standard for handling, storage and processing of combustible dust. This was intended to provide further detailed guidance to the industry beyond MOM's circular.

3.4.5. The Singapore Standard SS 667: Code of Practice for Handling, Storage and Processing of combustible dust was thus developed and launched in May 2021. This new standard included:

- a) Specific control measures to prevent combustible dust fire / explosion.
- b) New risk assessment approach for combustible dust. It is a systematic review to identify and evaluate the potential fire, flash fire and explosion hazards associated with the presence of one or more combustible dusts.
- c) Recommendation on electrical equipment zoning for the design of facilities with dust explosion hazard which make reference to international standard IEC 60079-10: Classification of Hazardous Areas.

3.4.6. This new Singapore Standard SS 667 will be gazetted as an Approved Code of Practice (“**ACOP**”) under the WSHA by December 2021. Under section 40C of the WSHA, regard shall be had to the relevant ACOPs in determining whether the obligations under the WSHA have been discharged. SCDF has also issued a circular to the industry requiring compliance to this new standard for new buildings / premises or alteration to existing buildings / premises that are submitted to SCDF for fire safety approval from 1 December 2021. Please refer to circular in [Annex C](#).

3.5 Recommendations

3.5.1. The appropriate technical control measures to prevent combustible dust explosion are already comprehensively covered by the new Singapore Standard SS 667. Hence, MOM will focus on enhancing the regulatory regime and proposes the following recommendations for IC’s consideration:

- (1) **Import and Supply:** Requiring suppliers to label materials with combustible dust hazards before selling or redistributing.
- (2) **Bulk Storage:** Requiring companies that handle a prescribed amount of specified combustible powders to register or notify the authorities.
- (3) **Usage:** Expanding duties on occupiers to declare to building owners and landlords on use of combustible powders as part of their operations.

3.6 Recommendation (1) – Import and Supply: Requiring Suppliers to Label Combustible Dust Hazards Before Selling or Redistributing

3.6.1. Notwithstanding the legal requirements and MOM’s circular in 2015, many companies have low awareness of combustible dust hazards, therefore there is a need to increase the level of awareness to the users. Learning from the practices of US and UK, MOM recommends that suppliers are required to label combustible dust hazards before selling or redistributing. This will increase awareness in users as to the combustible nature of the dusts handled, and alert them to the potential hazards.

3.6.2. Although there is already a requirement under section 16 of the WSHA to provide information relating to the hazardous substances, this does not apply to combustible dusts as it is not covered under Part II of the Fifth Schedule. As many combustible dusts are not inherently hazardous (e.g. flour and sugar), it may be confusing and inappropriate to classify them as hazardous substances.

- 3.6.3. A more pragmatic approach is to prescribe a separate list of combustible dusts (e.g. those with K_{st} value > 100) that are packed in quantities over a prescribed limit (e.g. >25 kg) to be subjected to such labelling requirements.

3.7 Recommendation (2) – Bulk Storage: Requiring Companies that Handle a Prescribed Amount of Specified Combustible Powders to register or notify the Authorities

- 3.7.1 As shown in [Table 3](#), SCDF currently licenses companies who store or use metallic combustible powders (such as aluminium, magnesium, zinc and iron carbonyl) under their Petroleum and Flammable Materials regime, while SFA regulates traders and importers of food products (some of which are combustible dusts) from a food safety perspective.
- 3.7.2 Having information on which workplace uses or handles combustible dust, especially in large quantities, will allow the authorities to inspect and intervene proactively to ensure that appropriate control measures are put in place. Therefore, MOM recommends that such “higher-risk” workplaces notify the authorities. The criteria for the notification requirement can be based on a prescribed list of combustible dusts and the quantity stored or used at the workplace.
- 3.7.3 Prescribing such a list based on both the combustible nature of the dust (*ie*, K_{st} value) as well as the quantities stored or used at the workplace provides a calibrated measure. It targets high-risk workplaces, while simultaneously avoiding placing an unnecessary burden on lower-risk workplaces, such as heartland bakeries which also use combustible powders but in much smaller quantities. As for higher-risk workplaces, these could be subjected to 3rd party audits by MOM-approved WSH Auditors to ensure adequate control measures are in place and are effective to prevent combustible dust explosions.
- 3.7.4 To augment the notification regime, we also recommend:
- a) Leveraging on building plan submissions by Qualified Persons (QP) to identify higher-risk workplaces during the upstream design or planning phase (new premises or expansion). This is so that control measures such as local exhaust ventilations can be designed and installed from the start rather than the subsequent retrofitting.

- b) Sharing information on suppliers, distributors, licensees, and occupiers that handle or store combustible powders at their workplaces amongst agencies such as SCDF, SFA or NEA.

3.7.5 This will build up a comprehensive database of workplaces that use / handle combustible dust and help authorities prioritise our resources to better target the higher-risk workplaces.

3.8 Recommendation (3) – Usage: Impose duties on Occupiers to alert Building Owners and Landlords on use of Combustible Powders as part of their Operations

3.8.1 The Stars fire and explosion resulted in significant damage to the building. Not only was Stars’s premises affected, but the blast also affected neighbouring units. It is therefore in the interest of the building owners to know if their tenants are using or handling combustible dusts.

3.8.2 Therefore, MOM recommends that occupiers of workplaces to inform their building owner or landlord when they are using materials which can pose combustible dust explosion risk within their premises. This will enhance the hazard communication on the use of combustible powders in workplaces. Building owners can then instruct their tenants to put in necessary control measures and deconflict if any of their tenants has incompatible work.

4 Theme B: Regulatory Regime on Safe Use of Industrial Machinery

4.1 Introduction

4.1.1 This section discusses the regulatory regime governing the safe use of industrial machinery under the WSHA and its application to the industrial kneader machine that was involved in the fire and explosion. This section also proposes some recommendations to strengthen the regulatory regime.

4.2 The Kneader Machine

4.2.1 The kneader machine is an industrial mixer. It was used by Stars for the heating and mixing of high viscosity materials for the purpose of manufacturing fire-retardant products. The kneader machine consisted of two main components:

- a) a mixing chamber, which contained a pair of rotating paddles arranged horizontally, rotating in opposite directions, driven by motor, for mixing of the materials placed within the mixing chamber, and
- b) a jacket to be filled with heat transfer medium, heated by electric heating elements, for heating of materials within the mixing chamber.

4.2.2 Stars bought the kneader machine online from a Chinese manufacturer. Stars also installed and commissioned the machine themselves in June 2020 after it was delivered.

4.3 Benchmarking of Singapore's regulatory regimes on safe use of machinery against other countries

4.3.1. Due to the wide variety of machineries, most overseas jurisdictions impose the primary duty of care to ensure the safety of the machinery on the employer (user). Some jurisdictions further impose duties on the designers, manufacturers, suppliers and installers of the machineries. Some jurisdictions also have specific requirements for a prescribed class of equipment (referred to as "statutory equipment") that are subjected to higher regulatory oversight.

4.3.2. A similar literature scan of the regulatory regime concerning the safe use of machinery was conducted for the 3 developed countries – US, UK and Australia. The findings are

summarised in [Table 6](#). Extracts of the relevant legislations are presented in [Annex D, E and F](#).

Table 6: Comparison of Regulatory Regime Governing the Safe Use of Machinery Used at Work across Jurisdictions

Areas	Findings
Duties of employer to ensure machine is safe to use	<ul style="list-style-type: none"> All countries including Singapore impose a general duty on the employers. In addition, Australia and Singapore also impose similar duty on the occupier of the workers.
Duties on manufacturer / suppliers ensure machine is safe to use when operated properly	<ul style="list-style-type: none"> UK and Australia impose such a duty on person who designs, manufactures, imports or supplies any equipment / machinery for work. Singapore imposes duty on person who manufactures or supplies a prescribed list of equipment / machinery for work (Part I of Fifth Schedule of WSHA) US does not have such a requirement.
Duties on Installers / Persons who modifies the machine	<ul style="list-style-type: none"> Only Australia imposes such a duty on persons who install any equipment / machinery for work. Singapore imposes a similar duty on persons who install or modify a prescribed list of equipment / machinery for work (Part I of Fifth Schedule of WSHA)
Statutory Equipment Regime	<ul style="list-style-type: none"> In Singapore, lifting equipment and pressure vessels, which can cause serious harm or damage if they fail during use, are required to be examined by competent persons before and at regular intervals during use. UK, Australia and US have similar examination requirements for lifting equipment and pressure vessels.

4.4 Current regulatory regimes on safe use of industrial machinery in Singapore

4.4.1. In Singapore, we adopt a 3-tier risk-based approach to regulate safe use of machinery at workplaces. [Table 7](#) summarises the regulatory requirements and classes of machinery for each tier of the regime.

Table 7: Regulatory Regime on Safe Use of Industrial Machinery under WSHA

Tier	Description	Regulatory Requirements
1	All machinery used at work <i>[including the kneader machine used by Stars]</i>	Duty on Owners, Occupiers, Principals and Employers to ensure that the machinery is safe.
2 (Medium risk)	11 classes of machinery specified in the <u>Fifth Schedule</u> of the WSHA E.g. forklifts, power presses, scaffolds	Additional duties are imposed on Manufacturers, Suppliers and Installers and Persons who modifies to ensure that: a) the machinery is safe when properly used; b) Information about the safe use of the machinery is available/adhered to; and c) The installation or modification is in accordance with the information supplied by the designer, manufacturer or supplier of the machinery.
3 (High risk)	2 classes of statutory equipment: a) Lifting Equipment (e.g. Cranes) b) Pressure vessels (e.g. Steam Boilers)	These equipment are individually registered, tested and examined by a MOM Authorised Examiner, before use and at regular intervals thereafter.
<p>Note: There is a parallel safety regime for 33 categories of general consumer products, where they are to be tested to specified safety standards and affixed with the “SAFETY Mark” before they can be sold in Singapore. This is governed under the Consumer Protection (Trade Descriptions and Safety Requirements) Act. These products are for personal, domestic consumption hence this regime is not applicable for industrial purposes.</p>		

Tier 1 – All Machinery used at work

4.4.2. The kneader machine used by Stars falls within tier 1 of the framework at present, as it does not come within any of the specified classes of machinery under the Fifth Schedule of the WSHA. For tier 1, which covers all machinery used at work, employers and occupiers of workplaces have duties under the WSHA to ensure safety and health in relation to the use of machinery. Employers are also legally bound to ensure that persons at work have adequate instruction, information, training and supervision for them to perform their work.

- 4.4.3. In the event that the operators are non-employees, the owners of machinery also have duties to make available the precautions to be taken for the safe use of the machinery to persons using the machinery and ensure that the machinery is maintained in a safe condition. An extract of the relevant sections of the WSHA is presented in [Annex G](#).

Tier 2 (Medium Risk) – 11 classes of Machinery and Equipment

- 4.4.4. Under tier 2, the 11 classes of machinery and equipment are specified in the Fifth Schedule of the WSHA ([Annex G](#)). There are additional duties imposed on manufacturers, suppliers and persons who erect, install or modify these machineries.
- 4.4.5. Manufacturers and suppliers shall make available information about the safe use of the machinery to persons to whom the machinery is supplied for use at work. This is to ensure that the machinery is safe when properly used and that the machinery is examined and tested: s 16 WSHA. In addition, any person who erects, installs or modifies these machineries is to ensure that the machinery is erected, installed or modified in such a manner that it is safe when properly used, and in accordance with the information supplied by the designer, manufacturer or supplier of the machinery: s 17 WSHA.

Tier 3 (High Risk) – 2 classes of Statutory Equipment

- 4.4.6. Tier 3 refers to the highest risk category of industrial machinery and are deemed “Statutory Equipment”. There are 2 classes of machinery under this category, namely lifting equipment and pressure vessels. Under the WSH (General Provisions) Regulations, these equipment are to be individually registered, tested and examined by a MOM Authorised Examiner before use and at regular intervals thereafter. An extract of the relevant regulations under tier 3 under the WSH (General Provisions) Regulations is given in [Annex G](#). The key features of the regulatory regime under tier 3 are summarised as follows:
- 4.4.7. *Registration Requirements:* As part of the conditions for registration, the owner of the statutory equipment shall ensure that the equipment is designed, constructed and tested in accordance with MOM-approved design standards or codes relevant to the equipment concerned. This includes the provision of the required safety devices to ensure the safe use of the equipment. The owner shall ensure that the equipment is examined, tested and registered by an Authorised Examiner to certify that the equipment is safe for intended use before it is put into operation. The owner shall de-register the statutory equipment once it is no longer in use.

- 4.4.8. Requirements for periodic test and examination by Authorised Examiners: Following the registration, the owner of the statutory equipment shall ensure that the equipment is periodically examined and tested by an Authorised Examiner at intervals stipulated under the WSH (General Provisions) Regulations and that a Certificate of Registration has been issued by the Authorised Examiner after each examination to certify that the equipment continues to be in good working condition and safe for intended use.
- 4.4.9. Requirements for approval for repairs or modification: The owner of the statutory equipment shall notify and seek approval from MOM before carrying out any repair or modification to any statutory equipment. In addition, these repairs and modification shall be supervised by an Authorised Examiner and a new Certificate of Registration shall be issued by the Authorised Examiner to certify that the equipment is in good working condition and safe for intended use after each repair or modification.
- 4.4.10. Requirements for Training and Competency of Operator: To ensure that no danger should arise due to improper or unsafe operation of the statutory equipment, the operator of the statutory equipment must be properly trained or competent to operate the equipment. For example, the operator of a mobile or tower crane must be the holder of a certificate of registration issued by MOM (MOM licensed crane operator) while an operator of a steam boiler must have successfully completed a training course acceptable to the Commissioner on the safe operation of the steam boiler.

4.5 Key considerations on adequacy of regulatory regime

- 4.5.1. Stars, being the owner of the kneader machine, the occupier of the workplace and the employer of the workers involved in the work, is responsible for discharging the duties under the WSHA. MOM is of the view that the current laws are adequate to address the lapses by Stars that have emerged from the evidence led in the first tranche of the inquiry hearing.
- 4.5.2. Nevertheless, there are 2 areas that warrant consideration:
- a) What can be done to ensure machines that are bought online are safe to use?
 - b) What can be done to ensure that owners who commission or repair the machines themselves are doing it correctly in accordance with the manufacturer's instructions or recommendations?

- 4.5.3. In today's globalised trade and economy, one can easily order and purchase an equipment online (locally or from overseas), and have it shipped to the premise. It is common to have the equipment installed or commissioned by the manufacturer or supplier as well as for the manufacturer / supplier to provide after-sales or maintenance support, especially if the equipment is costly and complex to operate. However, given the wide variety of industrial equipment and costs involved, such after-sales support may not always materialise, especially if the equipment is purchased from overseas.
- 4.5.4. In relation to the classes of equipment specified in the Fifth Schedule of the WSHA (see [4.4.4] above), if the buyer engages the supplier to provide the after-sales support to ensure that the equipment is properly installed, commissioned, and is safe to use, the provisions of the WSHA allow us to hold the supplier responsible for any safety lapses in provision of such services. However, if the buyer decides to forgo the after-sales support, the onus and responsibility to ensure the safety of the equipment rest squarely on him as the owner of the equipment.
- 4.5.5. Nevertheless, manufacturers and suppliers of equipment have a responsibility to ensure that their equipment are properly designed, safe to use when operated properly and that relevant information about their installation, commissioning, use, repair and modification are supplied to the buyer. Beyond legal or contractual responsibilities, it is also in the manufacturer's interest to ensure the quality of his equipment.
- 4.5.6. In addition, the law is unambiguous in that the employer is responsible to ensure that his employees receive adequate instruction, information, training and supervision as is necessary for them to perform their work safely, be it in commissioning, operating or repairing the equipment. The employer can engage the supplier or agent or an expert to train his employees to fulfil his duties.
- 4.5.7. In summary, it is too onerous and impractical to mandate after-sales support or regulate all imports of equipment to ensure that they safe to use. However, we can encourage owners of industrial equipment to engage competent parties to assist them. The owners of the equipment must adopt sound engineering principles in the handling of industrial machines, and they ought to seek technical support or assistance from the suppliers if they lack the knowledge or competency.

4.6 Recommendations

4.6.1 MOM therefore proposes the following recommendations for the IC's consideration:

- 1) Encourage buyers of industrial equipment to certify the equipment they purchase to Singapore Standard SS 537-1
- 2) Expand the Fifth Schedule of the WSHA to include more industrial equipment

4.7 Recommendation (1) – Encourage buyers of industrial equipment to certify the equipment they purchase to Singapore Standard SS 537-1

4.7.1. There is an existing Singapore Standard SS 537-1: Code of Practice for the Safe Use of Machinery – General Requirements that provides:

- a) Requirements on the design and manufacture of machinery to ensure that the machinery incorporates basic safety features.
- b) Guidance on the safety and health issues relating to the installation, testing, maintenance and servicing of machinery.
- c) Guidance on the methods for safeguarding the dangerous parts of machinery and enhancing safety in the use of machinery.

4.7.2. The SS 537-1 has been adopted as an ACOP under the WSHA. Therefore, MOM recommends that buyers of industrial equipment be encouraged to engage a 3rd party Testing Inspection or Certification (TIC) body to certify that the machine they had purchased conforms to the principles and guidance stipulated in the standard. Such a certification will provide an added assurance to the buyer if he chooses to forgo the after-sales support from the suppliers of the equipment, since section 40C of the WSHA provides that regard shall be had to the relevant ACOPs in determining whether the obligations under the WSHA have been discharged.

4.8 Recommendation (2) – Expand the Fifth Schedule of the WSHA to include more industrial equipment

4.8.1 The main components of the kneader machine (mixing chamber with heating oil jacket) can be found in a wide spectrum of industrial machines used at workplaces in various configurations, on different scales and for different applications. Despite the multiple casualties arising from the Stars explosion, the kneader machine is generally not a high-risk machine and may be used in a manner that is entirely safe. The primary cause of the accident was largely due to operational errors rather than the underlying design

of the machine. Hence, MOM is of the view that it would not be appropriate to classify the kneader machine as “Statutory Equipment” and subject it to the most stringent tier 3 regime.

- 4.8.2 Instead, MOM recommends expanding the Fifth Schedule of the WSHA to cover a broader range of industrial equipment such as those powered by mechanical, electrical, hydraulic or pneumatic energy. This will then subject more equipment, including the kneader machine, to the tier 2 regime. By doing so, duties will be imposed on the manufacturers, suppliers, installers and persons who modify these machines to ensure they are safe to use when operated properly and that relevant information about their installation, commissioning, use, repair and modification are supplied to the buyer.
- 4.8.3 It is also timely to review and update the Fifth Schedule as it has not been amended since the enactment of the WSHA in 2006 and the list of machinery and equipment may not adequately account for developments in machine designs, usage and safety features over the years. In the review, we will also assess the necessity to include the lower risk category of hand tools such as handheld grinders or drills.

5 Conclusion

- 5.1. The Stars fire and explosion was preventable. We will learn from this tragic accident and make improvements to the regulatory regime to prevent a recurrence. However, there is a limitation to any regulatory regime as it will never be exhaustive or comprehensive. Mandating requirements across all machine types and work processes will also lead to overregulation in certain sectors of the industry. This case underscores the importance of duty holders such as occupiers, employers, owners, manufacturers or suppliers of equipment taking **ownership** of workplace safety and health to prevent needless loss of lives and injuries to workers.
- 5.2. This is also why the Tripartite Strategies Committee emphasises the need to strengthen workplace safety and health ownership in the WSH2028 strategies to realise the vision of a healthy workforce in safe workplaces, a country renowned for best practices in Workplace Safety and Health.



WRITTEN SUBMISSION (PART 2 – ANNEXES)

*Inquiry Committee into Incident involving Fire and
Explosion at Stars Engrg Pte Ltd on 24 February 2021*

Include Annexes for:

Theme A: Regulatory Regime on Combustible Dust or Powders

Theme B: Regulatory Regime on Safety of Industrial Machinery

Prepared by OSHD

1 | Page

Contents

Annex A	Scan on Overseas Regulations on Combustible Dust.....	3
Annex B	Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts.....	23
Annex C	SCDF Circular on Implementation of SS 667: 2020 – Code of Practice for Handling, Storage and Processing of combustible dust.....	61
Annex D	US - Extracts from the Occupational Safety and Health Act of 1970 and related legislations	62
Annex E	UK - Extracts from the Health and Safety at Work etc. Act 1974 and related legislations	64
Annex F	Australia - Extracts from the Work Health and Safety Act 2011 and related legislations	75
Annex G	Singapore - Extracts from the Workplace Safety and Health Act and related legislations	96

Annex A Scan on Overseas Regulations on Combustible Dust

Duties of Manufacturer/ Supplier/Importer

Country	Act/Regulations	Extract of Act/Regulations on Duties of Manufacturer/ Supplier/Importer
UK HSE	<p>Health and Safety at Work etc. Act 1974</p> <p>Suppliers or manufacturers of flammable dusts that can explode, particularly where these are new substances, have a duty under section 6 to inform anyone to whom the substance is supplied about its properties. This may include the results of tests for explosibility.</p>	<p>6 General duties of manufacturers etc. as regards articles and substances for use at work.</p> <p>(4) It shall be the duty of any person who manufactures, imports or supplies any substance—</p> <p>(a) to ensure, so far as is reasonably practicable, that the substance will be safe and without risks to health at all times when it is being used, handled, processed, stored or transported by a person at work or in premises to which section 4 above applies;</p> <p>(b) to carry out or arrange for the carrying out of such testing and examination as may be necessary for the performance of the duty imposed on him by the preceding paragraph</p> <p>(c) to take such steps as are necessary to secure that persons supplied by that person with the substance are provided with adequate information about any risks to health or safety to which the inherent properties of the substance may give rise, about the results of any relevant tests which have been carried out on or in connection with the substance and about any conditions necessary to ensure that the substance will be safe and without risks to health at all such times as are mentioned in paragraph (a) above and when the substance is being disposed of; and</p> <p>(d) to take such steps as are necessary to secure, so far as is reasonably practicable, that persons so supplied are provided with all such revisions of information provided to them by virtue of the preceding paragraph as are necessary by reason of its becoming known that anything gives rise to a serious risk to health or safety.</p> <p>(5) It shall be the duty of any person who undertakes the manufacture of any substance to carry out or arrange for the carrying out of any necessary research with a view to the discovery and, so far as is</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Duties of Manufacturer/ Supplier/Importer
		<p>reasonable practicable, the elimination or minimisation of any risks to health or safety to which the substance may give rise at all such times as are mentioned in paragraph (a) of subsection (4) above.</p> <p>(6) Nothing in the preceding provisions of this section shall be taken to require a person to repeat any testing, examination or research which has been carried out otherwise than by him or at his instance, in so far as it is reasonable for him to rely on the results thereof for the purposes of those provisions.</p> <p>Health and Safety at Work etc. Act 1974 (legislation.gov.uk)</p>
<p>US OSHA</p>	<p>Hazard Communication Standard</p> <p>- Classification of products for combustible dust hazards</p> <p>Chemical manufacturers or importers to classify the hazards of chemicals which they produce or import.</p> <p>Where manufacturers are aware that the downstream use of their product routinely generates combustible dusts, a warning addressing a potential explosion hazard should be included on the label as an immediate visual reminder. SDS should also</p>	<p><i>1910.1200 (b)(1)</i></p> <p>This section requires chemical manufacturers or importers to classify the hazards of chemicals which they produce or import, and all employers to provide information to their employees about the hazardous chemicals to which they are exposed, by means of a hazard communication program, labels and other forms of warning, safety data sheets, and information and training. In addition, this section requires distributors to transmit the required information to employers. (Employers who do not produce or import chemicals need only focus on those parts of this rule that deal with establishing a workplace program and communicating information to their workers.)</p> <p><i>1910.1200(c) Definition</i></p> <p>Hazardous chemical means any chemical which is classified as a physical hazard or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise classified.</p> <p>Label means an appropriate group of written, printed or graphic information elements concerning a hazardous chemical that is affixed to, printed on, or attached to the immediate container of a hazardous chemical, or to the outside packaging.</p> <p>Safety data sheet (SDS) means written or printed material concerning a hazardous chemical that is prepared in accordance with paragraph (g) of this section.</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Duties of Manufacturer/ Supplier/Importer
	<p>include the potential explosion hazard.</p> <p>Hazard Communication Guidance for Combustible Dusts Occupational Safety and Health Administration (osha.gov)</p>	<p>1910.1200(d)</p> <p><i>Hazard classification.</i></p> <p><u>1910.1200(d)(1)</u></p> <p>Chemical manufacturers and importers shall evaluate chemicals produced in their workplaces or imported by them to classify the chemicals in accordance with this section. For each chemical, the chemical manufacturer or importer shall determine the hazard classes, and, where appropriate, the category of each class that apply to the chemical being classified. Employers are not required to classify chemicals unless they choose not to rely on the classification performed by the chemical manufacturer or importer for the chemical to satisfy this requirement.</p> <p><u>1910.1200(d)(2)</u></p> <p>Chemical manufacturers, importers or employers classifying chemicals shall identify and consider the full range of available scientific literature and other evidence concerning the potential hazards. There is no requirement to test the chemical to determine how to classify its hazards. Appendix A to § 1910.1200 shall be consulted for classification of health hazards, and Appendix B to § 1910.1200 shall be consulted for the classification of physical hazards.</p> <p>1910.1200 (f)(1)</p> <p>Labels on shipped containers. The chemical manufacturer, importer, or distributor shall ensure that each container of hazardous chemicals leaving the workplace is labeled, tagged, or marked. Hazards not otherwise classified do not have to be addressed on the container.</p> <p>1910.1200(g)(1)</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Duties of Manufacturer/ Supplier/Importer
		<p>Chemical manufacturers and importers shall obtain or develop a safety data sheet for each hazardous chemical they produce or import. Employers shall have a safety data sheet in the workplace for each hazardous chemical which they use.</p> <p>Application of OSHA's Amended Hazard Communication Standard (HCS 2012) to Combustible Dust (1910.1200)] Occupational Safety and Health Administration</p>
Australia	<p>Work Health and Safety Regulations 2011</p> <p>Labelling of hazardous chemicals classified under GHS. Combustible dust hazard is not a classification under GHS.</p>	<p>335 Labelling hazardous chemicals</p> <p>(1) The manufacturer or importer of a hazardous chemical must ensure that the hazardous chemical is correctly labelled as soon as practicable after manufacturing or importing the hazardous chemical.</p> <p>(2) A hazardous chemical is correctly labelled if the selection and use of label elements is in accordance with the GHS and it complies with Part 3 of Schedule 9.</p> <p>338 Supplier labelling hazardous chemicals</p> <p>The supplier of a hazardous chemical must not supply the hazardous chemical to another workplace if the supplier knows or ought reasonably to know that the hazardous chemical is not correctly labelled in accordance with regulation 335.</p> <p>339 Supplier to provide safety data sheets</p> <p>(1) The supplier of a hazardous chemical to a workplace must ensure that the current safety data sheet for the hazardous chemical is provided with the hazardous chemical:</p> <p>(a) when the hazardous chemical is first supplied to the workplace; and</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Duties of Manufacturer/ Supplier/Importer
		<p>(b) if the safety data sheet for the hazardous chemical is amended — when the hazardous chemical is first supplied to the workplace after the safety data sheet is amended.</p> <p>Hazardous chemical in the Regulations means a substance, mixture or article that satisfies the criteria for any one or more hazard classes in the GHS (including a classification referred to in Schedule 6 to these Regulations), unless the only hazard class or classes for which the substance, mixture or article satisfies the criteria are any one or more of the following:</p> <ul style="list-style-type: none"> (a) acute toxicity—oral—category 5; (b) acute toxicity—dermal—category 5; (c) acute toxicity—inhalation—category 5; (d) skin corrosion/irritation—category 3; (e) aspiration hazard—category 2; (f) flammable gas—category 2; (g) acute hazard to the aquatic environment—category 1, 2 or 3; (h) chronic hazard to the aquatic environment—category 1, 2, 3 or 4; (i) hazardous to the ozone layer. <p>Note: Schedule 9- Classification, packaging and labelling requirements</p> <p>Work Health and Safety Regulations 2011 (legislation.gov.au)</p>

Duties of Employer

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Duties of Employer
UK HSE	<p>Health and Safety at Work etc. Act 1974</p> <p>To ensure the safety of both employees and other people from the risks arising from the work activity, so far as is reasonably practicable.</p>	<p>1.1.1.1 <i>2 General duties of employers to their employees.</i></p> <p>(1) It shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees.</p> <p>(2) Without prejudice to the generality of an employer’s duty under the preceding subsection, the matters to which that duty extends include in particular—</p> <p>(a) the provision and maintenance of plant and systems of work that are, so far as is reasonably practicable, safe and without risks to health;</p> <p>(b) arrangements for ensuring, so far as is reasonably practicable, safety and absence of risks to health in connection with the use, handling, storage and transport of articles and substances;</p> <p>(c) the provision of such information, instruction, training and supervision as is necessary to ensure, so far as is reasonably practicable, the health and safety at work of his employees;</p> <p>(d) so far as is reasonably practicable as regards any place of work under the employer’s control, the maintenance of it in a condition that is safe and without risks to health and the provision and maintenance of means of access to and egress from it that are safe and without such risks;</p> <p>(e) the provision and maintenance of a working environment for his employees that is, so far as is reasonably practicable, safe, without risks to health, and adequate as regards facilities and arrangements for their welfare at work.</p> <p>Health and Safety at Work etc. Act 1974 (legislation.gov.uk)</p>
US OSHA	<p>OSH Act of 1970</p> <p>Furnish to each of his employees employment and a place of employment which</p>	<p>SEC. 5. Duties</p> <p>Each employer --</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Duties of Employer
	<p>are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees & comply with occupational safety and health standards promulgated under this Act</p>	<p>(1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;</p> <p>(2) shall comply with occupational safety and health standards promulgated under this Act.</p> <p>OSH Act of 1970 Occupational Safety and Health Administration</p>
<p>Australia</p>	<p>Work Health and Safety Act</p> <p>Employer/occupier must ensure, so far as reasonably practicable, the health and safety of persons at work</p>	<p>19 Primary duty of care</p> <p>(1) A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the health and safety of:</p> <p>(a) workers engaged, or caused to be engaged by the person; and</p> <p>(b) workers whose activities in carrying out work are influenced or directed by the person; while the workers are at work in the business or undertaking.</p> <p>(2) A person conducting a business or undertaking must ensure, so far as is reasonably practicable, that the health and safety of other persons is not put at risk from work carried out as part of the conduct of the business or undertaking.</p> <p>Work Health and Safety Act 2011 (legislation.gov.au)</p>

Hazardous area / atmosphere

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Hazardous area / atmosphere
UK HSE	<p>Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)</p> <p>Regulations applicable to:</p> <ul style="list-style-type: none"> any workplace where a potentially explosive atmosphere may occur. Workplaces where dangerous substances are present, used or produced. <p>Identification of hazardous zone for selection of equipment and protective systems to be used</p>	<p>Places where explosive atmospheres may occur</p> <p>7.—(1) Every employer shall classify places at the workplace where an explosive atmosphere may occur into hazardous or non-hazardous places in accordance with paragraph 1 of Schedule 2 and shall classify those places so classified as hazardous into zones in accordance with paragraph 2 of that Schedule; and that Schedule shall have effect subject to the notes at the end of that Schedule.</p> <p>(2) The employer shall ensure that the requirements specified in Schedule 3 are applied to equipment and protective systems in the places classified as hazardous pursuant to paragraph (1).</p> <p>(3) Where necessary, places classified as hazardous pursuant to paragraph (1) shall be marked by the employer with signs at their points of entry in accordance with Schedule 4.</p> <p>(4) Before a workplace containing places classified as hazardous pursuant to paragraph (1) is used for the first time, the employer shall ensure that its overall explosion safety is verified by a person who is competent in the field of explosion protection as a result of his experience or any professional training or both.</p> <p>(5) The employer shall ensure that appropriate work clothing which does not give rise to electrostatic discharges is provided for use in places classified as hazardous pursuant to paragraph (1).</p> <p>Note:</p> <p>Schedule 2 – Classification of places where explosive atmospheres may occur</p> <p>Schedule 3 - Criteria for the selection of equipment and protective systems</p> <p>Schedule 4 – Warning sign for places where explosive atmospheres may occur</p> <p>The Dangerous Substances and Explosive Atmospheres Regulations 2002 (legislation.gov.uk)</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Hazardous area / atmosphere
<p>US OSHA</p>	<p>1910.307 Hazardous (classified) locations</p> <p>Requirements for electric equipment and wiring in locations that are classified depending on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers that may be present therein and the likelihood that a flammable or combustible concentration or quantity is present.</p>	<p>1910.307(a)(1)</p> <p><i>Applicability.</i></p> <p>This section covers the requirements for electric equipment and wiring in locations that are classified depending on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers that may be present therein and the likelihood that a flammable or combustible concentration or quantity is present. Hazardous (classified) locations may be found in occupancies such as, but not limited to, the following: aircraft hangars, gasoline dispensing and service stations, bulk storage plants for gasoline or other volatile flammable liquids, paint-finishing process plants, health care facilities, agricultural or other facilities where excessive combustible dusts may be present, marinas, boat yards, and petroleum and chemical processing plants. Each room, section or area shall be considered individually in determining its classification.</p> <p>1910.307(c)</p> <p><i>Electrical installations.</i> Equipment, wiring methods, and installations of equipment in hazardous (classified) locations shall be intrinsically safe, approved for the hazardous (classified) location, or safe for the hazardous (classified) location. Requirements for each of these options are as follows:</p> <p>1910.307(c)(1)</p> <p><i>Intrinsically safe.</i> Equipment and associated wiring approved as intrinsically safe is permitted in any hazardous (classified) location for which it is approved;</p> <p>1910.307(c)(2)</p> <p><i>Approved for the hazardous (classified) location.</i></p> <p>1910.307(c)(2)(i)</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Hazardous area / atmosphere
		<p>Equipment shall be approved not only for the class of location, but also for the ignitable or combustible properties of the specific gas, vapor, dust, or fiber that will be present.</p> <p>1910.307 - Hazardous (classified) locations. Occupational Safety and Health Administration (osha.gov)</p>
Australia	<p>Work Health and Safety Regulations 2011</p> <p>Workplace must manage risks to health and safety associated with a hazardous atmosphere</p> <p>Hazardous atmosphere includes condition where combustible dust is present in a quantity and form that would result in a hazardous area</p>	<p>5 Definition</p> <p>hazardous area means an area in which:</p> <ul style="list-style-type: none"> (a) an explosive gas is present in the atmosphere in a quantity that requires special precautions to be taken for the construction, installation and use of plant; or (b) a combustible dust is present, or could reasonably be expected to be present, in the atmosphere in a quantity that requires special precautions to be taken for the construction, installation and use of plant. <p>51 Managing risks to health and safety</p> <ul style="list-style-type: none"> (1) A person conducting a business or undertaking at a workplace must manage risks to health and safety associated with a hazardous atmosphere at the workplace, in accordance with Part 3.1. <p>Note: WHS Act—section 19 (see regulation 9).</p> <ul style="list-style-type: none"> (2) An atmosphere is a hazardous atmosphere if: <ul style="list-style-type: none"> (a) the atmosphere does not have a safe oxygen level; or (b) the concentration of oxygen in the atmosphere increases the fire risk; or (c) the concentration of flammable gas, vapour, mist or fumes exceeds 5% of the LEL for the gas, vapour, mist or fumes; or

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Hazardous area / atmosphere
		(d) combustible dust is present in a quantity and form that would result in a hazardous area. Work Health and Safety Regulations 2011 (legislation.gov.au)

Control Measures to mitigate dust explosion

Country	Act/Regulations	Extract of Act/Regulations on Control Measures to mitigate dust explosion
UK HSE	<ul style="list-style-type: none"> • DSEAR + ACOP + Guidelines • The Fire Precautions (Workplace) Regulations 1997 • The Provision and Use of Work Equipment Regulations 1998 • The Workplace (Health, Safety and Welfare) Regulations 1992 • The Control of Substances Hazardous to Health Regulations 1999 • The Equipment and Protective Systems for Use in Potentially 	<p>1) Where a dangerous substance is or is liable to be present at the workplace, the employer shall make a suitable and sufficient assessment of the risks to his employees which arise from that substance.</p> <p>(2) The risk assessment shall include consideration of –</p> <p>(a) the hazardous properties of the substance;</p> <p>(b) information on safety provided by the supplier, including information contained in any relevant safety data sheet;</p> <p>(c) the circumstances of the work including –</p> <p>(i) the work processes and substances used and their possible interactions;</p> <p>(ii) the amount of the substance involved;</p> <p>(iii) where the work will involve more than one dangerous substance, the risk presented by such substances in combination; and</p> <p>(iv) the arrangements for the safe handling, storage and transport of dangerous substances and of waste containing dangerous substances;</p> <p>(d) activities, such as maintenance, where there is the potential for a high level of risk;</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Control Measures to mitigate dust explosion
	<p>Explosive Atmospheres Regulations 1996</p>	<p>(e) the effect of measures which have been or will be taken pursuant to these Regulations;</p> <p>(f) the likelihood that an explosive atmosphere will occur and its persistence;</p> <p>(g) the likelihood that ignition sources, including electrostatic discharges, will be present and become active and effective;</p> <p>(h) the scale of the anticipated effects of a fire or an explosion;</p> <p>(i) any places which are or can be connected via openings to places in which explosive atmospheres may occur; and</p> <p>(j) such additional safety information as the employer may need in order to complete the risk assessment.</p> <p>(3) The risk assessment shall be reviewed by the employer regularly so as to keep it up to date and particularly if –</p> <p>(a) there is reason to suspect that the risk assessment is no longer valid; or</p> <p>(b) there has been a significant change in the matters to which the risk assessment relates including when the workplace, work processes, or organisation of the work undergoes significant changes, extensions or conversions;</p> <p>and where, as a result of the review, changes to the risk assessment are required, those changes shall be made.</p> <p>(4) Where the employer employs five or more employees, the employer shall record the significant findings of the risk assessment as soon as is practicable after that assessment is made, including in particular –</p> <p>(a) the measures which have been or will be taken by him pursuant to these Regulations;</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Control Measures to mitigate dust explosion
		<p>(b) sufficient information to show that the workplace and work processes are designed, operated and maintained with due regard for safety and that, in accordance with the Provision and Use of Work Equipment Regulations 1998, adequate arrangements have been made for the safe use of work equipment; and</p> <p>(c) where an explosive atmosphere may occur at the workplace and subject to the transitional provisions in regulation 17(1) to (3), sufficient information to show –</p> <ul style="list-style-type: none"> (i) those places which have been classified into zones pursuant to regulation 7(1); (ii) equipment which is required for, or helps to ensure, the safe operation of equipment located in places classified as hazardous pursuant to regulation 7(1); (iii) that any verification of overall explosion safety required by regulation 7(4) has been carried out; and (iv) the aim of any co-ordination required by regulation 11 and the measures and procedures for implementing it. <p>The Dangerous Substances and Explosive Atmospheres Regulations 2002 (legislation.gov.uk)</p>
<p>US OSHA</p>	<p><u>OSHA Standards Regulations</u></p> <ul style="list-style-type: none"> • Housekeeping and Related Standards • Equipment Standards Applicable to Combustible Dust • Electrical (Hazard) Class II Standards 	<p>OSHA’s <i>Grain Handling Facilities</i> standard 29 CFR 1910.272 has requirements for limiting dust accumulations in grain handling facilities.</p> <p>29 CFR1910.272(j)(2)(ii)</p> <p>The employer shall immediately remove any fugitive grain dust accumulations whenever they exceed 1/8 inch (0.32 cm) at priority housekeeping areas, pursuant to the housekeeping program, or shall demonstrate and assure, through the development and implementation of the housekeeping program, that equivalent protection is provided.”</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Control Measures to mitigate dust explosion
	<p>Other OSHA Standards Applicable to Combustible Dust Inspections</p> <ul style="list-style-type: none"> • 29 CFR 1910.132, <i>Personal Protective Equipment General Requirements</i> • 29 CFR 1910.178, <i>Powered Industrial Trucks</i> • 29 CFR 1910, Subpart Q, <i>Welding, Cutting and Brazing</i> • 29 CFR 1910.1200, <i>Hazard Communication</i>. 	<p>29 CFR 1910.272(j)(1)</p> <p>The employer shall develop and implement a written housekeeping program that establishes the frequency and method(s) determined best to reduce accumulations of fugitive grain dust on ledges, floors, equipment, and other exposed surfaces.</p> <p>1910.272 - Grain handling facilities. Occupational Safety and Health Administration (osha.gov)</p> <p>29 CFR 1910.22, <i>Walking-Working Surfaces General Requirements</i></p> <p>1910.22(a)(2)</p> <p>The floor of each workroom is maintained in a clean and, to the extent feasible, in a dry condition. When wet processes are used, drainage must be maintained and, to the extent feasible, dry standing places, such as false floors, platforms, and mats must be provided.</p> <p>1910.22(a)(3)</p> <p>Walking-working surfaces are maintained free of hazards such as sharp or protruding objects, loose boards, corrosion, leaks, spills, snow, and ice.</p> <p>1910.22 - General requirements. Occupational Safety and Health Administration (osha.gov)</p> <p>1910.94 Ventilation</p> <p>1910.94(c)</p> <p><i>Spray finishing operations.</i></p> <p>1910.94(c)(2)</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Control Measures to mitigate dust explosion
		<p><i>Location and application.</i> Spray booths or spray rooms are to be used to enclose or confine all operations. Spray-finishing operations shall be located as provided in sections 201 through 206 of the Standard for Spray Finishing Using Flammable and Combustible Materials, NFPA No. 33-1969.</p> <p>29 CFR 1910.261, <i>Pulp, Paper, and Paperboard Mills</i>, applies to dust control for rag and old paper preparation, see (f)(5). This standard also has requirements for sulfur dust explosion hazards, see (g)(1)(i), (g)(1)(iii), and (a)(3)(viii).</p> <p>1910.261(f)(5), <i>Dust</i>. Measures for the control of dust shall be provided, in accordance with American National Standards Z33.1—1961, Z87.1—1968, and Z88.2—1969.</p> <p>1910.261(g)(1)(i), Sulfur-burner houses shall be safely and adequately ventilated, and every precaution shall be taken to guard against dust explosion hazards and fires, in accordance with American National Standards Z9.2—1960 and Z12.12—1968.</p> <p>1910.261(g)(1)(ii), Nonsparking tools and equipment shall be used in handling dry sulfur.</p> <p>1910.261(g)(1)(iii), Sulfur storage bins shall be kept free of sulfur dust accumulation, in accordance with American National Standard Z9.2—1960.</p> <p>1910.261 - Pulp, paper, and paperboard mills. Occupational Safety and Health Administration (osha.gov)</p> <p>29 CFR 1910.263, <i>Bakery Equipment</i>. See paragraph (k)(2) for sugar and spice pulverizer requirements. See paragraphs (d)(3)(v), (d)(6)(ii), (d)(7)(iii), (d)(8)(i) for fugitive dust emission prevention requirements for flour handling equipment.</p> <p>1910.263(k)(2)</p> <p>Sugar and spice pulverizers.</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Control Measures to mitigate dust explosion
		<p>1910.263(k)(2)(i)</p> <p>All drive belts used in connection with sugar and spice pulverizers shall be grounded by means of metal combs or other effective means of removing static electricity. All pulverizing of sugar or spice grinding shall be done in accordance with NFPA 62-1967 (Standard for Dust Hazards of Sugar and Cocoa) and NFPA 656-1959 (Standard for Dust Hazards in Spice Grinding Plants), which are incorporated by reference as specified in Sec. 1910.6.</p> <p>1910.263(k)(2)(ii)</p> <p>Magnetic separators shall be provided to reduce fire and explosion hazards.</p> <p>1910.263(d)(3)(v)</p> <p>All dumpbin and blender hoods shall be of sufficient capacity to prevent circulation of flour dust outside the hoods.</p> <p>1910.263(d)(6)(ii)</p> <p>Storage bins shall be provided with gaskets and locks or latches to keep the cover closed, or other equivalent devices in order to insure the dust tightness of the cover. Covers at openings where an employee may enter the bin shall also be provided with a hasp and a lock, so located that the employee may lock the cover in the open position whenever it is necessary to enter the bin.</p> <p>1910.263(d)(7)(iii)</p> <p>The covers of all screw conveyors shall be made removable in convenient sections, held on with stationary clamps located at proper intervals keeping all covers dust-tight. Where drop or hinged bottom sections are provided this provision shall not apply.</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Control Measures to mitigate dust explosion
		<p>1910.263(d)(8)(i)</p> <p>Enclosures of all types of flour sifters shall be so constructed that they are dust-tight but readily accessible for interior inspection.</p> <p>1910.263 - Bakery equipment. Occupational Safety and Health Administration (osha.gov)</p> <ul style="list-style-type: none"> • 29 CFR 1910.265, <i>Sawmills</i>. See paragraphs (c)(20)(ii) through (vi) on collecting systems, exhaust and conveyor systems, and dust systems. <p>1910.265(c)(20)</p> <p><i>Blower, collecting, and exhaust systems—</i></p> <p>1910.265(c)(20)(i)</p> <p>Design, construction, and maintenance. Blower collecting, and exhaust systems should be designed, constructed, and maintained in accordance with American National Standards Z33.1—1961 (For the Installation of Blower and Exhaust Systems for Dust, Stock, and Vapor Removal or Conveying) and Z12.2—1962 (R1969) (Code for the Prevention of Dust Explosion in Woodworking and Wood Flour Manufacturing Plants), which are incorporated by reference as specified in §1910.6.</p> <p>1910.265(c)(20)(ii)</p> <p><i>Collecting systems.</i> All mills containing one or more machines that create dust, shavings, chips, or slivers during a period of time equal to or greater than one-fourth of the working day, shall be equipped with a collecting system. It may be either continuous or automatic, and shall be of sufficient strength and capacity to enable it to remove such refuse from points of operation and immediate vicinities of machines and work areas.</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Control Measures to mitigate dust explosion
		<p>1910.265(c)(20)(iii)</p> <p><i>Exhaust or conveyor systems.</i> Each woodworking machine that creates dust, shavings, chips, or slivers shall be equipped with an exhaust or conveyor system located and adjusted to remove the maximum amount of refuse from the point of operation and immediate vicinity.</p> <p>1910.265(c)(20)(v)</p> <p><i>Dust chambers.</i> Exhaust pipes shall not discharge into an unconfined outside pile if uncontrolled fire or explosion hazards are created. They may empty into settling or dust chambers, designed to prevent the dust or refuse from entering any work area. Such chambers shall be constructed and operated to minimize the danger of fire or dust explosion.</p> <p>1910.265(c)(20)(vi)</p> <p><i>Hand removal of refuse.</i> Provision for the daily removal of refuse shall be made in all operations not required to have an exhaust system or having refuse too heavy, bulky, or otherwise unsuitable to be handled by the exhaust system.</p> <p>1910.265 - Sawmills. Occupational Safety and Health Administration (osha.gov)</p> <ul style="list-style-type: none"> • 29 CFR 1910.269, <i>Electric Power Generation, Transmission, and Distribution</i>, applies to combustible dust inspections at coal-fired electric power generating stations. This standard, see subparagraph 1910.269(v)(11)(xii), should be used for <i>Electrical (Hazard) Class II Considerations</i> at coal-fired electric power generating stations. <p>1910.269(v)(11)(xii)</p> <p>Where coal-handling operations may produce a combustible atmosphere from fuel sources or from flammable gases or dust, sources of ignition shall be eliminated or safely controlled to prevent ignition of</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Control Measures to mitigate dust explosion
		<p>the combustible atmosphere.</p> <p>Note to paragraph (v)(11)(xii): Locations that are hazardous because of the presence of combustible dust are classified as Class II hazardous locations. See § 1910.307.</p> <p>1910.269 - Electric power generation, transmission, and distribution. Occupational Safety and Health Administration (osha.gov)</p>
<p>Australia</p>	<ul style="list-style-type: none"> • Work Health and Safety Regulations • Dangerous Goods Safety Act 	<p>Work Health and Safety Regulations</p> <p>Regulation 51-52: A person conducting a business or undertaking must manage the risk to health and safety associated with a hazardous atmosphere or an ignition source in a hazardous atmosphere at the workplace.</p> <p>Dangerous Goods Safety Act (Western Australia)</p> <p>Section 8 – Person involved in storing, handling or transporting DG must take all reasonably practicable measures to minimize risk to people, property and environment.</p> <p>Section 20 Codes of practice, approval of</p> <p>(1) For the purpose of providing practical guidance to persons engaged, directly or indirectly, in storing, handling, or transporting dangerous goods, the Minister may approve any code of practice as in force from time to time or as in force at a particular time.</p> <p>(2) A code of practice –</p> <p>(a) may consist of any code, standard, rule, specification or provision relating to the storage, handling or transport of dangerous goods published by a body recognised as having an expertise on the subject; and</p> <p>(b) may incorporate by reference any other such document as in force from time to time or as in force at a particular time.</p>

Annex A Scan on Overseas Regulations on Combustible Dust

Country	Act/Regulations	Extract of Act/Regulations on Control Measures to mitigate dust explosion
		https://www.slp.wa.gov.au/gazette/gg.nsf/gaz/B7ADFF1DA908CF4648258280004D23E?openDocument

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Singapore Civil Defence Force (SCDF)

Singapore Civil Defence Force (SCDF) implements licensing controls over petroleum and flammable materials (P&FM) that are listed under the Fire Safety Act and the Fire Safety (Petroleum & Flammable Materials) Regulations. Companies are required to apply for a P&FM storage licence, which is renewable once every year. This is to help ensure fire safety compliance for the storage of P&FM, minimize fire safety risk through safe handling of these substances and ensure that there are proper emergency response procedures put in place. The current list of petroleum and flammable materials included metal powders such as aluminum, magnesium and zinc, which are combustible powders.

For new built and buildings where works carried out will affect the fire safety works within the building, building plan approval has to be sought from SCDF and the fire safety measures are required to comply with the Fire Code requirements. This will also apply to buildings or premises that may use or store combustible powders.

Singapore Food Agency (SFA)

Singapore Food Agency (SFA) administers the Sale of Food Act and the Singapore Food Regulations to ensure that the food made available for sale in Singapore are safe for consumption. Part of SFA's regime involves the implementation of controls on commercial food imports that enter Singapore including process food some of which are combustible dusts. Examples of processed food include:

- Infant formula
- Milk products (eg. cheese, milk powder, etc.)
- Biscuits
- Flour
- Cereals
- Coffee powder

There are labelling requirements for pre-packed food and the labels aim to provide consumers with basic information of the product such as the source, nature and contents, quantity and quality. Under the Food Regulations, these labels need to include details such as the ingredients used.

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Ministry of Manpower (MOM)

Under the Workplace Safety and Health Act and its subsidiary legislations, MOM ensures that workers' safety and health is safeguarded in workplaces. Currently, there are provisions under the WSH (General Provisions) Regulations on precautions and measures to be taken with regards to explosive, flammable dust, gas, vapour or substance. Combustible dust which could cause combustible dust explosion are also included under this clause. However, it was not explicitly stated in the clause that combustible dust is part of flammable dust. There is also no requirement for the occupier handling combustible dust to inform MOM or other agencies on the use of such material except for those flammable solids which are licensed under SCDF.

The Workplace Safety and Health Act (WSHA) covers duties of manufacturer and supplier of hazardous substances prescribed in the Fifth Schedule to provide information on the safe use of the hazardous substance. Additionally, the WSH (General Provisions) Regulations also require seller or agent of the seller of the hazardous substances to provide Safety Data Sheet that conforms to Singapore Standard SS 586 Part 3: Preparation of Safety Data Sheets (SDS), which conforms to the GHS. This is to ensure proper hazard communication to users of hazardous substances on the potential hazards and precautionary measures to take when handling and storing of these substances. As GHS classification does not include combustible dust hazard as one of the hazard classifications, chemicals which are toxic substances and pose combustible dust hazard, the label for the product will only cover the toxicity hazard but not combustible dust hazard. In addition, food products such as milk powder, plain flour are not deemed as hazardous substances, warning labels would not apply.

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
Customs	Regulation of Imports and Exports Act	Import	<p>All goods entering Singapore goes through Customs</p> <p>Regulations for registration, regulation and control of importation and exportation, etc.</p> <p>3.—(1) The Minister may make regulations for the registration, regulation and control of all or any class of goods imported into, exported from, transhipped in or in transit through Singapore.</p> <p style="text-align: right;"><i>[6/2003 wef 01/04/2003]</i></p> <p>(2) Without prejudice to the generality of subsection (1), the Minister may make regulations —</p> <p style="padding-left: 20px;">(a) for prohibiting, absolutely or conditionally, or for regulating, in all cases or in any specified case or class of cases and subject to such exceptions as may be made by the regulations, the import</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>or export or the carriage coastwise or the shipment as ships' stores or the transhipment or transit of all goods or of goods of any specified class or description;</p> <p>(b) for imposing on such importers, exporters, agents, forwarding agents, common carriers, consignors or consignees of goods or on owners, agents, masters or persons in charge of a conveyance as may be prescribed in the regulations, the duty to furnish —</p> <p style="padding-left: 40px;">(i) to the Director-General; or <i>[6/2003 wef 01/04/2003]</i></p> <p style="padding-left: 40px;">(ii) to the owner, agent, master or person in charge of a conveyance, or to a railway station-master or to such other person as may be prescribed,</p> <p>such particulars, information or documents relating to goods imported into, exported from, transhipped in or in transit through Singapore as may be prescribed;</p> <p>(c) for permitting the Director-General to authorise, in such manner as may be prescribed, the importation, exportation, transhipment or transit of goods in regard to which the required particulars, information or documents have been furnished; <i>[6/2003 wef 01/04/2003]</i></p> <p>(d) for prohibiting the importation, exportation, transhipment or transit of goods, or the delivery of goods or of documents relating to such goods, except in compliance with the regulations or with the approval of the Director-General; <i>[6/2003 wef 01/04/2003]</i></p> <p>(da) for prohibiting the exportation of all goods or goods of any specified class or description except in compliance with such conditions as may be prescribed for the purpose of complying with any</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>preferential tariff arrangement or agreement between Singapore and a country or territory outside Singapore, including any condition that the goods exported are to be from a prescribed source or that the manufacture of such goods is to be carried out or procured by any person registered under regulations made under this Act;</p> <p style="text-align: right;"><i>[28/2003 wef 01/01/2004]</i></p> <p>(e) for requiring the owner or agent of any conveyance to furnish particulars of coal, oil or other fuel or stores placed on board that conveyance in Singapore;</p> <p>(f) for determining the form and manner in which the required particulars, information and documents shall be furnished;</p> <p>(g) for prescribing the time within which the required particulars, information and documents shall be furnished;</p> <p>(h) for requiring the master of any vessel to attend at an examination station or the office of the Port Master, and to furnish such particulars, information and documents, as may be prescribed;</p> <p style="text-align: right;"><i>[6/2003 wef 01/04/2003]</i></p> <p>(i) for prohibiting the issue of a port clearance to the master of any vessel pending compliance with any provision of the regulations;</p> <p>(j) for the registration of all or such class of goods, as may be prescribed, imported into, exported from, transhipped in or in transit through Singapore;</p> <p>(k) for the registration of importers, exporters, common carriers of goods or any person making a declaration under this Act or any regulations made thereunder;</p> <p style="text-align: right;"><i>[Act 3 of 2014 wef 01/04/2014]</i></p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(l) for the issue of certificates of entitlement to permits for the export or import of such classes of goods, as are prescribed, to successful applicants who submitted bids for the certificates;</p> <p>(m) for requiring fees and deposits to be paid for the submission of applications for the issue of certificates of entitlement under any regulations made under paragraph (l), and providing for the forfeiture of deposits for non-compliance with any of the conditions governing the submission of such applications;</p> <p>(n) for prescribing the levy, or the method or manner for determining the amount of the levy, payable for the import or export of different classes of goods or for a certificate of entitlement issued under any regulations made under paragraph (l) and for prescribing the manner or method in which such levy shall be paid;</p> <p>(na) for requiring security to be provided to secure compliance with this Act, any regulations made thereunder or any condition imposed under this Act or such regulations, and to make provision for the form, manner, amount, period and forfeiture of such security; [28/2003 wef 01/01/2004]</p> <p>(o) for prescribing the fees and charges, or the method or manner for determining the amount of the fees or charges, payable by virtue of any regulations made under this section, and for prescribing the manner or method in which such fees or charges shall be paid;</p> <p>(p) for prescribing the fees to be charged for services and facilities provided by the Director-General; [28/2003 wef 01/01/2004] [6/2003 wef 01/04/2003]</p> <p>(pa) for the bringing of appeals to the Minister in respect of any matter referred to in this Act or any regulations made thereunder, and the procedure for such appeals; and</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p style="text-align: right;"><i>[28/2003 wef 01/01/2004]</i></p> <p>(q) for prescribing anything which is required to be prescribed under this Act or which is necessary or expedient to be prescribed for carrying out or giving effect to the provisions of this Act.</p> <p style="text-align: right;"><i>[6/2003 wef 01/04/2003]</i></p>
Customs	Regulation of Imports and Exports Regulations	Import	<p>Import permit/licence from respective agencies required in order to allow goods to enter Singapore</p> <p>Permit for import, export or transhipment</p> <p>3.—(1) Subject to paragraphs (2), (2A), (3) and (4) and regulation 5A, no goods shall be —</p> <p style="padding-left: 40px;">(a) imported into Singapore;</p> <p style="padding-left: 40px;">(b) exported out of Singapore; or</p> <p style="padding-left: 40px;">(c) transhipped in Singapore,</p> <p>except in accordance with a permit granted by the Director-General under this Part.</p> <p style="text-align: right;"><i>[S 370/2013 wef 01/07/2013]</i> <i>[S 645/2017 wef 08/11/2017]</i></p> <p>(2) The requirement in paragraph (1) for a permit to import, export or tranship any goods shall not apply if such goods are not controlled imports, controlled exports or controlled transhipments and are —</p> <p style="padding-left: 40px;">(a) personal or household effects, other than motor vehicles, which —</p> <p style="padding-left: 80px;">(i) accompany passengers, crew or employees of transport undertakings by land, sea or air;</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<ul style="list-style-type: none"> (ii) are not being transported for sale but are intended for the personal or household use of such passengers, crew or employees of transport undertakings; and (iii) in the case of such household effects, are being transported for the purpose of a transfer of residence of the owner to Singapore or to a place outside Singapore; <p>(b) being imported, exported or transhipped by parcel post;</p> <p>(c) diplomatic correspondence;</p> <p>(d) being imported, exported or transhipped by —</p> <ul style="list-style-type: none"> (i) the joint defence force, including the Singapore Armed Forces, the Singapore Police Force and the Singapore Civil Defence Force, including personal and household effects of its officers but excluding civilian motor vehicles; or (ii) the Ministry of Foreign Affairs, including personal and household effects of its officers but excluding motor vehicles; <p>(e) used motor vehicles covered by Carnet de Passage which are endorsed by the Automobile Association of Singapore;</p> <p>(f) trade samples, specimens for analysis or test, and gifts, the total value of which does not exceed \$400;</p> <p>(g) commercial, shipping or airline documents, press photographs or negatives, news write-ups, news clippings, news films or news transcription tapes;</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(h) human corpses, human remains, human bones or cremated ashes; or [S 370/2013 wef 01/07/2013]</p> <p>(i) human transplant materials. [S 370/2013 wef 01/07/2013]</p> <p>(2A) The requirement in paragraph (1) for a permit to import any goods shall not apply if such goods —</p> <p>(a) are not controlled imports;</p> <p>(b) have a total value which does not exceed \$400; and</p> <p>(c) are being imported by air. [S 370/2013 wef 01/07/2013]</p> <p>(3) The requirement in paragraph (1) for a permit to export any goods shall not apply if such goods —</p> <p>(a) are not controlled exports;</p> <p>(b) have a total value which does not exceed \$1,000; and [S 370/2013 wef 01/07/2013]</p> <p>(c) are being exported by air. [S 370/2013 wef 01/07/2013]</p> <p>(4) The requirement in paragraph (1) for a permit to tranship any goods shall not apply to goods —</p> <p>(a) which are not controlled transshipments; and</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(b) which —</p> <ul style="list-style-type: none"> (i) are not transhipped from one free trade zone to another; or (ii) are carried by air to and from Singapore during transshipment, and have a total value which does not exceed \$1,000.
Customs	Regulation of Imports and Exports Regulations	Import	<p>Application for import certificate</p> <p>28.—(1) An application for the issue of an import certificate under this regulation shall be —</p> <ul style="list-style-type: none"> (a) made by an importer of goods, whether he is the end-user or not; (b) made in such manner as the Director-General may determine; (c) made in triplicate in such form as the Director-General may determine with particulars of — <ul style="list-style-type: none"> (i) the quantity, value and a complete description of the goods to be imported; (ii) the name and address of the end-user of the goods; and (iii) such undertaking or other information as the Director-General may require; and (d) accompanied by — <ul style="list-style-type: none"> (i) a declaration by the foreign exporter that the goods are subject to the export control of the exporting country; and (ii) such information or document as the Director-General may require.

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(2) An import certificate issued by the Director-General under this regulation shall be in duplicate and shall be valid for the period specified in the certificate and shall be subject to such conditions as the Director-General may impose.</p> <p>(3) The Director-General may at any time vary or add to the conditions imposed under paragraph (2).</p> <p>(4) The validity of an import certificate may, on the application of the importer concerned before the expiry of the certificate, be extended for such period of time as the Director-General thinks fit. <i>[S 170/2003 wef 01/04/2003]</i></p> <p>(5) Any person who breaches an undertaking given under paragraph (1)(c)(iii) or a condition imposed by this regulation shall be guilty of an offence.</p>
SCDF	Fire Safety Act	Import, distribution (transport)	<p>Import, transport licence for petroleum and flammable materials under the Act</p> <p>Import of petroleum and flammable materials</p> <p>35A.—(1) No person shall import any class of petroleum or any flammable material if —</p> <p>(a) the regulations require the person importing such petroleum or flammable material to hold a licence from the Commissioner to import such petroleum or flammable material; and</p> <p>(b) the person does not hold such a valid licence.</p> <p>(2) No person shall import any class of petroleum or any flammable material unless the importation —</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(a) is effected in accordance with the provisions of his licence and with every condition specified therein; and</p> <p>(b) is in such quantities and in such manner and in accordance with requirements prescribed in relation to such petroleum or flammable material.</p> <p style="text-align: right;"><i>[Act 14 of 2013 wef 01/09/2013]</i> <i>[7/2004 wef 16/02/2005]</i></p> <p>Transport of petroleum and flammable materials</p> <p>35B.—(1) No person shall transport any class of petroleum or any flammable material (other than as a driver of a road vehicle) if —</p> <p>(a) the regulations require the person transporting such petroleum or flammable material to hold a licence from the Commissioner to transport such petroleum or flammable material; and</p> <p>(b) the person does not hold such a valid licence.</p> <p>(2) No person shall transport any class of petroleum or any flammable material (other than as a driver of a road vehicle) unless the transportation —</p> <p>(a) is in accordance with the provisions of his licence and with every condition specified therein; and</p> <p>(b) is in such quantities and in such manner and in accordance with requirements prescribed in relation to such petroleum or flammable material.</p> <p style="text-align: right;"><i>[Act 14 of 2013 wef 01/09/2013]</i></p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(3) No person shall drive any vehicle transporting any class of petroleum or any flammable material by road if —</p> <p>(a) the regulations require the vehicle to be licensed to transport such petroleum or flammable material and the vehicle is not licensed by the Commissioner to carry such petroleum or flammable material; and</p> <p>(b) the regulations require the person to hold a permit from the Commissioner to drive a vehicle carrying such petroleum or flammable material and the person does not hold such a valid permit.</p> <p>(4) No person shall drive any vehicle transporting any class of petroleum or any flammable material by road unless he does so in such manner and in accordance with requirements prescribed in relation to such petroleum or flammable material, and in accordance with the provisions of his permit and every condition specified therein.</p> <p style="text-align: right;"><i>[Act 14 of 2013 wef 01/09/2013]</i></p> <p>(5) Nothing in this section shall apply to petroleum or any flammable material in the fuel tank of a vehicle which is used or intended to be used as fuel for that vehicle.</p> <p>(6) Every permit issued by the Commissioner before the date of commencement of section 16 of the Fire Safety (Amendment) Act 2004 authorising any person to drive any vehicle transporting any class of petroleum or any flammable material by road shall be deemed to have been issued under subsection (3)(b).</p> <p style="text-align: right;"><i>[7/2004 wef 16/02/2005]</i></p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
SCDF	Fire Safety Act	Storage, Use	<p>Storage of petroleum and flammable materials</p> <p>35. No person shall store or keep, or cause to be stored or kept, any class of petroleum or any flammable material except —</p> <p>(a) in or on licensed premises; <i>[Act 14 of 2013 wef 01/09/2013]</i></p> <p>(b) in such quantities and in such manner and in accordance with requirements prescribed in relation to such petroleum or flammable material; and <i>[Act 14 of 2013 wef 01/09/2013]</i></p> <p>(c) under the authority of and in accordance with the provisions of a storage licence from the Commissioner and every condition specified therein. <i>[Act 14 of 2013 wef 01/09/2013]</i> <i>[7/2004 wef 16/02/2005]</i></p> <p>Pipelines for petroleum and flammable materials</p> <p>36A. No pipeline owner shall convey, or allow the conveyance of, any class of petroleum or any flammable material through any section of a relevant pipeline in relation to which he is the pipeline owner except under the authority of and in accordance with the provisions of a pipeline licence from the Commissioner and every condition specified therein.</p>
SCDF	Fire Safety (Petroleum and Flammable)	Distribution (Transport)	<p>Application for licence to transport petroleum or flammable materials</p> <p>5.—(1) An application for a licence to transport any petroleum or flammable material or both in a vehicle shall be made by the person intending to transport the petroleum or flammable material or both.</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
	Materials) Regulations		<p>(2) A separate application for a licence to transport any petroleum or flammable material or both shall be made in respect of each particular vehicle in which the petroleum or flammable material or both are to be transported; and each such application shall also be regarded as an application for a licence for that vehicle to transport the petroleum or flammable material or both.</p> <p>(3) Subject to paragraphs (4) and (5), every application for a licence to transport any petroleum or flammable material or both in a vehicle shall be accompanied by the following documents:</p> <ul style="list-style-type: none"> (a) a test certificate on the roadworthiness of the vehicle issued by the Land Transport Authority of Singapore under section 90 of the Road Traffic Act (Cap. 276); (b) a copy of the Transport Emergency Response Plan for that vehicle; (c) a certificate of inspection of that vehicle from an approved inspector; (d) a list of drivers to be employed by the applicant to transport petroleum or flammable materials in that vehicle; <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p> <ul style="list-style-type: none"> (e) if required by the Commissioner, a quantitative risk assessment or any other risk analysis report on the transport of the petroleum or flammable materials in the vehicle from any person who in the view of the Commissioner is qualified to give such report; and <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p> <ul style="list-style-type: none"> (f) such other documents or particulars as the Commissioner may require in any particular case. <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p> <p>(4) Where the application is for a licence to transport any petroleum or flammable material or both in bulk, the application shall be accompanied by the following additional documents:</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(a) the manufacturer's specifications and design plans of the tank to be used in the transport;</p> <p>(b) a hydrostatic test report or any equivalent test report, certified in accordance with an accepted code of practice by a professional engineer in the mechanical engineering discipline or by such other person acceptable to the Commissioner;</p> <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p> <p>(ba) a radiographic test report or any equivalent test report of the tank, certified in accordance with an accepted code of practice by a professional engineer in the mechanical engineering discipline or by any other person acceptable to the Commissioner; and</p> <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p> <p>(c) a copy of the plan of the vehicle showing the following particulars:</p> <ul style="list-style-type: none"> (i) the location of the vehicle engine, fuel tank, exhaust system and pipe, batteries and pump or compressor (if any) and where any of these components are encased, the type of material used to encase them, and the type of material that is used to construct the rear portion of the driver's cab facing the tank; (ii) the water capacity of the vehicle's tank; (iii) the location and nature of all openings, fittings, gauges, emergency shut-off valves, excess flow valves, or any other safety valves or devices and their means of closure and capacities, where applicable; and (iv) the location, size and type of all fire extinguishers provided in the vehicle.

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(5) Where the application is for a licence to transport petroleum or flammable materials in package, the application shall be accompanied by the following additional documents:</p> <p>(a) a letter from the applicant certifying that —</p> <p style="padding-left: 40px;">(i) he has checked the vehicle which is to be used to transport the petroleum or flammable material; and</p> <p style="padding-left: 40px;">(ii) he is satisfied that the condition of the vehicle is in compliance with the Act and these Regulations; and</p> <p>(b) a letter of authorisation from the supplier of the petroleum to be transported, if the applicant is not a supplier.</p> <p>(6) Where the applicant for a licence to transport any petroleum or flammable material or both in any vehicle is not the owner of the vehicle, the application shall also be accompanied by the consent in writing of the owner of the vehicle or of the legal personal representative, if the owner is deceased.</p> <p>(7) Paragraph (4)(b) shall not apply to an application for the renewal of a licence to transport any petroleum or flammable material or both in a vehicle if, within the 5 years prior to that application, the applicant has complied with that provision on at least one occasion either when making an application for the licence or an application for the renewal of the licence.</p> <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p> <p>(8) Paragraph (4)(ba) shall not apply to an application for the renewal of a licence to transport any petroleum or flammable material or both in a vehicle if, within the 10 years prior to that application, the applicant has complied with that provision on at least one occasion either when making an application for the licence or an application for the renewal of the licence.</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
SCDF	Fire Safety (Petroleum and Flammable Materials) Regulations	Import	<p>Import of petroleum or flammable materials in excess of Second Schedule quantity requires licence</p> <p>15. The import of any class of petroleum or any flammable material in excess of the respective quantities specified in the Second Schedule shall require a licence to import.</p>
SCDF	Fire Safety (Petroleum and Flammable Materials) Regulations	Storage	<p>Application for licence to store or keep petroleum or flammable materials</p> <p>4.—(1) An application for a licence to store or keep any petroleum or flammable material or both at any premises shall be made by the person intending to store or keep the petroleum or flammable material or both.</p> <p>(2) A separate application for a licence to store or keep any petroleum or flammable material or both shall be made in respect of each particular premises at which the petroleum or flammable material or both are to be stored or kept; and each such application shall also be regarded as an application for a licence for those premises to store or keep that petroleum or flammable material or both.</p> <p>Application for pipeline licence</p> <p>4A.—(1) An application for a pipeline licence to convey any class of petroleum or flammable material through any section of a relevant pipeline shall be made by the pipeline owner of that section of the relevant pipeline.</p>
SCDF	Fire Safety Act	Use, Storage	<p>Prohibition of fire safety works without approval of plans</p> <p>24.—(1) A person must not carry out, or permit or authorise the carrying out of, any fire safety works —</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
		(Building Work approval)	<p>(a) before the Commissioner has approved all the plans of the fire safety works under section 23; or</p> <p>(b) otherwise than in accordance with the plans approved under section 23.</p> <p style="text-align: right;"><i>[Act 22 of 2019 wef 14/09/2020]</i></p>
SCDF	Fire Safety (Building and Pipeline Fire Safety) Regulations	Use, Storage (Building Work approval)	<p>Application for approval of plans of fire safety works</p> <p>3. For the purposes of section 23(1) of the Act, an application for the approval of plans of any fire safety works shall be in such form as the Commissioner may provide and shall be accompanied by the prescribed fees and by the following documents:</p> <p>(a) the following plans of fire safety works:</p> <ul style="list-style-type: none"> (i) building plans (where the fire safety works relate to any building) or relevant pipeline plans (where the fire safety works relate to any relevant pipeline); <p style="text-align: right;"><i>[S 545/2013 wef 01/09/2013]</i></p> <ul style="list-style-type: none"> (ii) air-conditioning and mechanical ventilation plans; and (iii) fire protection plans; <p>(b) a notification signed by the applicant of the appointment of —</p> <ul style="list-style-type: none"> (i) the qualified person who prepared the plans of fire safety works; and (ii) where the plans of fire safety works contain any alternative solution, the fire safety engineer who prepared or supervised the preparation of the plans,

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p style="text-align: right;"><i>[S 545/2013 wef 01/09/2013]</i></p> <p>and a confirmation of such appointment signed by the qualified person and, where applicable, the fire safety engineer;</p> <p>(c) the applicable declaration form set out on the website at https://www.scdf.gov.sg;</p> <p style="text-align: right;"><i>[S 769/2020 wef 14/09/2020]</i></p> <p>(d) where the plans of fire safety works contain any alternative solution, the additional following documents:</p> <ul style="list-style-type: none"> (i) a fire safety engineering design brief; (ii) a fire safety engineering report, including detailed specifications and drawings of the final design of fire safety works; (iii) an operations and maintenance manual for the building or relevant pipeline, as the case may be, to which the fire safety works relate; <p style="text-align: right;"><i>[S 545/2013 wef 01/09/2013]</i></p> <ul style="list-style-type: none"> (iv) a notification signed by the applicant of the appointment of a peer reviewer and a confirmation of such appointment signed by the peer reviewer; and (v) a peer reviewer's report as to whether the alternative solution satisfies the fire performance requirements in the Fire Code; <p style="text-align: right;"><i>[S 545/2013 wef 01/09/2013]</i> <i>[S 769/2020 wef 14/09/2020]</i></p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(e) where the plans of fire safety works involve the use of any building materials or equipment not specified in the Fire Code — a description of the nature and type of all the building materials or equipment to be used in the fire safety works;</p> <p style="text-align: right;"><i>[S 769/2020 wef 14/09/2020]</i></p> <p>(f) other documentary evidence in support of any documents in paragraphs (a) to (e), and such other documents as the Commissioner may require to decide the application.</p>
SFA	Sale of Food Act	Import, Distribution	<p>(Requires labelling based on food safety/quality considerations)</p> <p>Offences concerning labelling</p> <p>16.—(1) A person must not sell any food that is packaged or labelled in a manner that does not comply with all applicable requirements of this Act relating to identification and labelling of that food.</p>
SFA	Food Regulations	Import, Distribution	<p>General requirements for labelling</p> <p>5.—(1) No person shall import, advertise, manufacture, sell, consign or deliver any prepacked food if the package of prepacked food does not bear a label containing all the particulars required by these Regulations.</p> <p>(2) Every package of prepacked food shall, unless otherwise provided in these Regulations, bear a label, marked on or securely attached in a prominent and conspicuous position to the package, containing such particulars, statements, information and words in English as are required by the Act and these Regulations.</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(3) The particulars, statements, information and words referred to in paragraph (2) shall appear conspicuously and in a prominent position on the label and shall be clearly legible.</p> <p>(4) The particulars referred to in paragraph (3) shall include —</p> <p>(a) the common name, or a description (in the case where a suitable common name is not available) sufficient to indicate the true nature of the food;</p> <p>(b) the appropriate designation of each ingredient in the case of food consisting of two or more ingredients and unless the quantity or proportion of each ingredient is specified, the ingredients shall be specified in descending order of the proportions by weight in which they are present. For the purpose of this subparagraph —</p> <p style="padding-left: 40px;">(i) “appropriate designation” means a name or description, being a specific and not a generic name or description, which shall indicate to a prospective purchaser the true nature of the ingredient, constituent or product to which it is applied except as provided in the First Schedule;</p> <p style="padding-left: 40px;">(ii) it shall not be necessary to state that the food contains water; and</p> <p style="padding-left: 40px;">(iii) where a food contains an ingredient which is made from two or more constituents, the appropriate designations of those constituents shall be so specified and it shall not be necessary to specify the appropriate designation of that ingredient;</p> <p>(c) either one of the following statements in specification of ingredients in the case of a food which contains the synthetic colouring, tartrazine:</p> <p style="padding-left: 40px;">(i) tartrazine;</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(ii) colour (102);</p> <p>(iii) colour (FD&C Yellow #5) or other equivalent terms;</p> <p>(d) the net quantity of the food in the wrapper or container expressed in the following manner: (i) for liquid foods, by volume;</p> <p>(ii) for solid foods, by weight;</p> <p>(iii) for semi-solid or viscous foods, either by weight or volume; and</p> <p>(iv) for a food packed in a liquid medium, by net weight of the food together with the liquid medium, and by drained weight of the food.</p>
SFA	Feeding Stuffs Act	Use, Storage	<p>Licence to import, manufacture, etc., animal feeds</p> <p>4.—(1) The Director-General may issue a licence to any person to import, manufacture, process for sale or sell simple feeds, feed concentrates or compound feeds upon an application made in the prescribed form and the payment of such fees as may be prescribed.</p> <p>(2) A licence shall be subject to such conditions as may be prescribed and such other conditions as the Director-General may, in his discretion, impose.</p> <p>(3) The Director-General may, in his discretion, at any time, revoke or suspend a licence.</p> <p>(4) No person shall import, manufacture, process for sale or sell simple feeds, feed concentrates or compound feeds without a licence issued by the Director-General.</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
MOM	Workplace Safety and Health Act	Use, Storage	<p>Duty of occupier of workplace</p> <p>11. It shall be the duty of every occupier of any workplace to take, so far as is reasonably practicable, such measures to ensure that —</p> <ul style="list-style-type: none"> (a) the workplace; (b) all means of access to or egress from the workplace; and (c) any machinery, equipment, plant, article or substance kept on the workplace, <p>are safe and without risks to health to every person within those premises, whether or not the person is at work or is an employee of the occupier.</p> <p>Duties of employers</p> <p>12.—(1) It shall be the duty of every employer to take, so far as is reasonably practicable, such measures as are necessary to ensure the safety and health of his employees at work.</p> <p>(2) It shall be the duty of every employer to take, so far as is reasonably practicable, such measures as are necessary to ensure the safety and health of persons (not being his employees) who may be affected by any undertaking carried on by him in the workplace.</p> <p>(3) For the purposes of subsection (1), the measures necessary to ensure the safety and health of persons at work include —</p> <ul style="list-style-type: none"> (a) providing and maintaining for those persons a work environment which is safe, without risk to health, and adequate as regards facilities and arrangements for their welfare at work; (b) ensuring that adequate safety measures are taken in respect of any machinery, equipment, plant, article or process used by those persons; (c) ensuring that those persons are not exposed to hazards arising out of the arrangement, disposal, manipulation, organisation, processing, storage, transport, working or use of things —

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(i) in their workplace; or (ii) near their workplace and under the control of the employer;</p> <p>(d) developing and implementing procedures for dealing with emergencies that may arise while those persons are at work; and (e) ensuring that those persons at work have adequate instruction, information, training and supervision as is necessary for them to perform their work.</p> <p>Duties of manufacturers and suppliers of machinery, equipment or hazardous substances used at work</p> <p>16.—(1) Subject to this section, it shall be the duty of any person who manufactures or supplies any machinery, equipment or hazardous substance for use at work to ensure, so far as is reasonably practicable —</p> <p>(a) that the following information about the safe use of the machinery, equipment or hazardous substance is available to any person to whom the machinery, equipment or hazardous substance is supplied for use at work:</p> <p>(i) the precautions (if any) to be taken for the proper use and maintenance of the machinery, equipment or hazardous substance;</p> <p>(ii) the health hazards (if any) associated with the machinery, equipment or hazardous substance; and</p> <p>(iii) the information relating to and the results of any examinations or tests of the machinery, equipment or hazardous substance under paragraph (c) that are relevant to its safe use;</p> <p>(b) that the machinery, equipment or hazardous substance is safe, and without risk to health, when properly used;</p> <p>(c) that the machinery, equipment or hazardous substance is examined and tested so as to comply with the obligation imposed by paragraph (b).</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>List of Hazardous Substances under WSHA</p> <p>The list of hazardous substances as specified in the Fifth Schedule of the WSH Act is as follow:</p> <p style="text-align: center;">PART II</p> <p style="text-align: center;">HAZARDOUS SUBSTANCES</p> <ol style="list-style-type: none"> 1. Corrosive substances 2. Flammable substances 3. Explosives 4. Oxidising substances 5. Pyrophoric substances 6. Gases under pressure 7. Organic peroxides 8. Self heating substances 9. Self-reactive substances 10. Substances which in contact with water, emit flammable gases 11. Toxic substances 12. Mutagens 13. Carcinogens 14. Teratogens

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>15. Sensitizers</p> <p>16. Irritants</p> <p>17. Substances hazardous to aquatic environment.</p>
MOM	Workplace Safety and Health (Risk Management) Regulations	Use/Storage	<p>3. Risk assessment</p> <p>(1) In every workplace, the employer, self-employed person and principal shall conduct a risk assessment in relation to the safety and health risks posed to any person who maybe affected by his undertaking in the workplace.</p> <p>(2) The Commissioner may determine the manner in which the risk assessment referred to in paragraph (1) is to be conducted.</p>
MOM	Workplace Safety and Health (General Provisions) Regulations	Use, storage	<p>Precautions with regard to explosive or flammable dust, gas, vapour or substance</p> <p>26. —(1) Where any process in a plant used in a workplace gives rise to dust, gas, vapour or substance that may escape into any place of work and the dust, gas, vapour or substance that may escape is of such a character and is to such an extent as to be liable to explode on ignition —</p> <p>(a) all reasonably practicable steps shall be taken to prevent such an explosion —</p> <p>(i) by enclosure of the plant used in the process;</p> <p>(ii) by removal or prevention of accumulation of the dust, gas, vapour or substance;</p> <p>(iii) by exclusion or effective enclosure of possible sources of ignition; or</p> <p>(iv) by the use of suitable flame-proof equipment; and</p> <p>(b) unless the plant in which the process is carried out is so constructed as to withstand the pressure likely to be produced by any such explosion, all reasonably practicable steps shall be taken to restrict the spread and effects of such an explosion by the provision of chokes, baffles and vents, or other equally effective appliances in the plant.</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(2) Where any part of a plant in a workplace contains any explosive or flammable gas or vapour under pressure greater than atmospheric pressure, that part shall not be opened, unless it is positively isolated, depressurised and vented to a safe location, and where necessary, purged to remove any residual gas or vapour.</p> <p>(3) No plant, tank or vessel in a workplace that contains, or has contained, any explosive or flammable substance shall be subjected to —</p> <ul style="list-style-type: none"> (a) any welding, brazing or soldering operation; (b) any cutting operation which involves the application of heat; or (c) any operation involving the application of heat for the purpose of taking apart or removing the plant, tank or vessel or any part of it, until all reasonably practicable steps have been taken to remove the substance and any fumes, gas or vapour arising from it, or to render the substance and fumes non-explosive and non-flammable. <p>Warning labels</p> <p>42. It shall be the duty of the occupier of a workplace in which there is any container of hazardous substances to ensure that, so far as reasonably practicable, every such container is affixed with one or more warning labels that conform with —</p> <ul style="list-style-type: none"> (a) any Singapore Standard relating to the classification and labelling of hazardous substances; or (b) such other standards, codes of practice or guidance relating to the classification and labelling of hazardous substances as is issued or approved by the Council.

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>Safety data sheet</p> <p>43. —(1) Where any hazardous substance is used, handled or stored in a workplace, it shall be the duty of the occupier of the workplace to —</p> <ul style="list-style-type: none"> (a) obtain a safety data sheet of the substance; (b) assess the information in the safety data sheet and take precautionary measures to ensure the safe use of the substance; and (c) make available the safety data sheet to all persons at work in the workplace who are liable to be exposed to the substance. <p>(2) Where any hazardous substance is sold to any person for use in a workplace, it shall be the duty of the seller or any agent of the seller who caused or procured the sale to provide the buyer with a safety data sheet for the substance that —</p> <ul style="list-style-type: none"> (a) gives accurate and adequate information on the substance; and (b) conforms with any Singapore Standard relating to safety data sheets or such other standards, codes of practice or guidance as is issued or approved by the Council. <p>“hazardous substance” means any hazardous substance specified in Part II of the Fifth Schedule to the Act</p>
MOM	Workplace Safety and Health (Major Hazard Installations) Regulations	Use, Storage	<p>Implementation of safety case</p> <p>6. Subject to regulation 11(4), the occupier of a major hazard installation or deemed major hazard installation must implement the safety case for the major hazard installation or deemed major hazard installation by doing all of the following:</p> <ul style="list-style-type: none"> (a) implement the major accident prevention policy for the major hazard installation or deemed major hazard installation;

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(b) ensure that the person mentioned in paragraph 1(b) of Part 2 of the Third Schedule carries out the roles and responsibilities specified in that paragraph;</p> <p>(c) implement the plan mentioned in paragraph 1(d) of Part 2 of the Third Schedule;</p> <p>(d) implement the safety and health management system in accordance with the Workplace Safety and Health (Safety and Health Management System and Auditing) Regulations 2009 (G.N. No. S 607/2009);</p> <p>(e) ensure that the necessary resources, mentioned in paragraph 3 of Part 2 of the Third Schedule, are available for implementing the major accident prevention policy;</p> <p>(f) implement the preventive measures mentioned in paragraph 5(a) of Part 2 of the Third Schedule;</p> <p>(g) ensure that the processes carried out in the major hazard installation or deemed major hazard installation are carried out in accordance with the description in paragraph 5(b) of Part 2 of the Third Schedule;</p> <p>(h) operate the major hazard installation or deemed major hazard installation in accordance with the description mentioned in paragraph 6(f) of Part 2 of the Third Schedule;</p> <p>(i) implement the measures mentioned in paragraph 7 of Part 2 of the Third Schedule.</p>
NEA	Environmental Protection and Management Act	Use, Storage (Development control)	<p>Written permission for use of scheduled premises</p> <p>6.—(1) No person shall occupy or use any scheduled premises specified in the First Schedule without a written permission granted by the Director-General.</p> <p>(2) Any person who contravenes subsection (1) shall be guilty of an offence.</p> <p>(3) Any application for a written permission under this section shall be made to the Director-General giving details of —</p> <p>(a) the trade, industry or process proposed to be carried in or on the premises;</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(b) the measures the applicant undertakes to adopt to control air, water and noise pollution from the premises; and</p> <p>(c) the measures the applicant undertakes to adopt to manage hazardous substances and to treat and dispose of toxic substances originating from or stored within the premises.</p> <p>Permit for certain works on scheduled premises</p> <p>8.—(1) The owner or occupier of any scheduled premises shall not without a permit granted by the Director-General —</p> <p>(a) alter the method of operation of any trade or industrial process, fuel burning equipment, control equipment, treatment plant or industrial plant in or on the scheduled premises;</p> <p>(b) install, alter or replace any fuel burning equipment, control equipment, treatment plant or industrial plant in or on the scheduled premises;</p> <p>(c) erect or alter the height or dimension of any chimney through which air impurities may be emitted from the scheduled premises; or</p> <p>(d) use any fuel other than the type of fuel specified in writing by the Director-General.</p> <p>First Schedule</p> <p>Scheduled Premises</p> <p>Scheduled premises are any premises —</p> <p>(a) being used for —</p> <p>(i) cement works, being works for the manufacture or packing of portland cement, similar cement or pozzolanic materials;</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<ul style="list-style-type: none"> (ii) concrete works, being works for the manufacture of concrete and of each batch capacity greater than 0.5 cubic metre; (iii) asphalt works, being works for the manufacture of asphalt or tarmacadam; (iv) ceramic works, being works in which any products such as bricks, tiles, pipes, pottery goods, refractories or glass are manufactured in furnaces or kilns fired by any fuel; (v) chemical works, being works in which acids, alkali, chemical fertilizer, soap, detergent, sodium silicates, lime or other calcium compounds, chlorine, chemicals or chemical products are manufactured; (vi) coke or charcoal works, being works in which coke or charcoal is produced and quenched, cut, crushed or graded; (vii) ferrous and non-ferrous metal works, being works in which metal melting process for casting and/or metal coating are carried out; (viii) gas works, being works in which coal, coke, oil or other mixtures or derivatives are handled or prepared for carbonisation or gasification and in which such materials are subsequently carbonised or gasified; (ix) crushing, grinding and milling works, being works in which rock, ores, minerals, chemicals or natural grain products are processed by crushing, grinding, milling or separating into different sizes by sieving, air elutriation or in any other manner; (x) petroleum works, being works in which crude or shale oil or crude petroleum or other mineral oil is refined or reconditioned; (xi) scrap metal recovery works, being works in which scrap metals are treated in any type of furnace for recovery of metal irrespective of whether this is the primary object of any specific premises or not; (xii) primary metallurgical works, being works in which ores are smelted or converted to metal of any kind;

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(xiii) pulping works, being works in which wood or cellulose material is made into pulp;</p> <p>(xiv) abrasive blasting works, being works in which equipment or structures are cleaned by abrasive blasting;</p> <p>(b) on which there is erected any boiler of steam generating capacity of 2,300 kilogrammes or more per hour, incinerator or furnace burning 500 kilogrammes or more of solid combustible material per hour or 220 kilogrammes or more of liquid material per hour; or</p> <p>(c) being used or intended to be used for storing —</p> <p>(i) more than 100 tonnes of one or more of the following substances: chemicals, chemical products, hydrocarbons or hydrocarbon products which are toxic or which produce toxic gases on burning or on contact with water or air; or</p> <p>(ii) more than 1,000 tonnes of one or more of the following substances: chemicals, chemical products, hydrocarbons or hydrocarbon products with a flash point lower than 55°C.</p>
NEA	Environmental Protection and Management (Air Impurities) Regulations	Use	<p>Standards of concentration of air impurities</p> <p>4.—(1) For the purposes of section 12 of the Act, the standards of concentration of air impurities that must be complied with in the conduct of any trade, industry or process or the operation of any fuel burning equipment or industrial plant shall be those specified in the Schedule.</p> <p>(2) The concentration of any substance specified in the first column of the Schedule shall be determined in accordance with such method as may be specified by or is acceptable to the Director-General.</p> <p>The Schedule</p>

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations																					
			<p style="text-align: center;">STANDARDS OF CONCENTRATION OF AIR IMPURITIES</p> <p>1. The concentration of any substance specified in the first column emitted from any operation in any trade, industry, process, fuel burning equipment or industrial plant specified in the second column shall not at any point before admixture with air, smoke or other gases, exceed the limits specified in the third column.</p> <table border="1"> <thead> <tr> <th><i>Substance</i></th> <th><i>Trade, industry, process, fuel burning equipment or industrial plant</i></th> <th><i>Emission limits</i></th> </tr> </thead> <tbody> <tr> <td>(a) Ammonia and ammonium compounds</td> <td>Any trade, industry or process</td> <td>30 mg/Nm³ expressed as ammonia</td> </tr> <tr> <td>(b) Antimony and its compounds</td> <td>Any trade, industry or process</td> <td>5 mg/Nm³ expressed as antimony</td> </tr> <tr> <td>(c) Arsenic and its compounds</td> <td>Any trade, industry or process</td> <td>1 mg/Nm³ expressed as arsenic</td> </tr> <tr> <td>(d) Benzene</td> <td>Any trade, industry or process</td> <td>5 mg/Nm³</td> </tr> <tr> <td>(e) Cadmium and its compounds</td> <td>Any trade, industry or process</td> <td>0.05 mg/Nm³ expressed as cadmium</td> </tr> <tr> <td>(f) Carbon monoxide</td> <td>Any trade, industry, process or fuel burning equipment</td> <td>250 mg/Nm³</td> </tr> </tbody> </table>	<i>Substance</i>	<i>Trade, industry, process, fuel burning equipment or industrial plant</i>	<i>Emission limits</i>	(a) Ammonia and ammonium compounds	Any trade, industry or process	30 mg/Nm ³ expressed as ammonia	(b) Antimony and its compounds	Any trade, industry or process	5 mg/Nm ³ expressed as antimony	(c) Arsenic and its compounds	Any trade, industry or process	1 mg/Nm ³ expressed as arsenic	(d) Benzene	Any trade, industry or process	5 mg/Nm ³	(e) Cadmium and its compounds	Any trade, industry or process	0.05 mg/Nm ³ expressed as cadmium	(f) Carbon monoxide	Any trade, industry, process or fuel burning equipment	250 mg/Nm ³
<i>Substance</i>	<i>Trade, industry, process, fuel burning equipment or industrial plant</i>	<i>Emission limits</i>																						
(a) Ammonia and ammonium compounds	Any trade, industry or process	30 mg/Nm ³ expressed as ammonia																						
(b) Antimony and its compounds	Any trade, industry or process	5 mg/Nm ³ expressed as antimony																						
(c) Arsenic and its compounds	Any trade, industry or process	1 mg/Nm ³ expressed as arsenic																						
(d) Benzene	Any trade, industry or process	5 mg/Nm ³																						
(e) Cadmium and its compounds	Any trade, industry or process	0.05 mg/Nm ³ expressed as cadmium																						
(f) Carbon monoxide	Any trade, industry, process or fuel burning equipment	250 mg/Nm ³																						

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations		
			(g) Chlorine	Any trade, industry or process	32 mg/Nm ³
			(h) Copper and its compounds	Any trade, industry or process	5 mg/Nm ³ expressed as copper
			(i) Dioxins and furans	Any waste incinerator	(i) 1.0 ng TEQ/Nm ³ for waste incinerators commissioned before 1st January 2001 (ii) 0.1 ng TEQ/Nm ³ for waste incinerators commissioned on or after 1st January 2001
			(j) Ethylene oxide	Any trade, industry or process	5 mg/Nm ³
			(k) Fluorine, hydrofluoric acid or inorganic fluorine compounds	Any trade, industry or process	10 mg/Nm ³ expressed as hydrofluoric acid
			(l) Formaldehyde	Any trade, industry or process	20 mg/Nm ³
			(m) Hydrogen chloride	Any trade, industry or process	200 mg/Nm ³
			(n) Hydrogen sulphide	Any trade, industry or process	7.6 mg/Nm ³
			(o) Lead and its compounds	Any trade, industry or process	0.5 mg/Nm ³ expressed as lead

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations		
			(p) Mercury and its compounds	Any trade, industry or process	0.05 mg/Nm ³ expressed as mercury
			(q) Oxides of nitrogen	Any trade, industry, process or fuel burning equipment	400 mg/Nm ³ expressed as nitrogen dioxide
			(r) Particulate substances including smoke, soot, dust, ash, fly-ash, cinders, cement, lime, alumina, grit and other solid particles of any kind	Any trade, industry, process, fuel burning equipment or industrial plant (except for any cold blast foundry cupolas)	(i) 50 mg/Nm ³ ; or (ii) where there is more than one flue, duct or chimney in any scheduled premises, the total mass of the particulate emissions from all of such flue, duct or chimney divided by the total volume of such emissions shall not exceed 50 mg/Nm ³ and the particulate emissions from each of such flue, duct or chimney shall not exceed 100 mg/Nm ³ at any point in time.
			(s) Styrene monomer	Any trade, industry or process	100 mg/Nm ³

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations		
			(t) Sulphur dioxide (non-combustion sources)	Any trade, industry or process	500 mg/Nm ³
			(ta) Sulphur dioxide (combustion sources)	Any trade, industry or process	(i) 1,700 mg/Nm ³ (ii) where there is more than one flue, duct or chimney in any scheduled premises, the total mass of the sulphur dioxide emissions from all of such flue, duct or chimney divided by the total volume of such emissions must not exceed 1,700 mg/Nm ³ on a daily basis.
			(u) Sulphur trioxide and other acid gases	The manufacture of sulphuric acid	500 mg/Nm ³ expressed as sulphur trioxide. Effluent gases shall be free from persistent mist.
			(v) Sulphur trioxide or sulphuric acid mist	Any trade, industry or process, other than any combustion process and any plant involving the manufacture of sulphuric acid	100 mg/Nm ³ expressed as sulphur trioxide

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations			
			<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%; padding: 5px;">(w) Vinyl chloride monomer</td> <td style="width: 40%; padding: 5px;">Any trade, industry or process</td> <td style="width: 30%; padding: 5px;">20 mg/Nm³</td> </tr> </table> <p style="text-align: right; color: blue; font-size: small;">[S 369/2015 wef 01/07/2015]</p>	(w) Vinyl chloride monomer	Any trade, industry or process	20 mg/Nm ³
(w) Vinyl chloride monomer	Any trade, industry or process	20 mg/Nm ³				
NEA	Environmental Public Health Act	Disposal	<p>Dangerous substance or toxic industrial waste not to be brought to disposal facility without permission</p> <p>29.—(1) No person who owns or is in possession of any dangerous substance or toxic industrial waste or the residue from the treatment thereof shall bring or cause to be brought such substance or waste to any disposal facility for disposal without the written permission of the Director-General.</p> <p style="text-align: right; color: blue; font-size: small;">[2/96; 4/2002]</p> <p>Licensing of persons carrying on business of collecting, removing, etc., of refuse or waste</p> <p>31.—(1) No person shall carry on the business of collecting, removing, transporting, storing or importing refuse or waste of any description without a waste collector licence granted by the Director-General under this section.</p> <p style="text-align: right; color: blue; font-size: small;">[2/96; 4/2002]</p> <p>(2) The Director-General may grant a licence authorising any person to carry on the business of collecting, removing, transporting, storing or importing refuse or waste of any description.</p> <p style="text-align: right; color: blue; font-size: small;">[2/96; 4/2002]</p>			
NEA	Environmental Public Health (Toxic Industrial Waste) Regulations	Disposal	<p>No person to act as toxic industrial waste collector without licence</p> <p>9. No person shall —</p> <p style="padding-left: 40px;">(a) carry on or advertise, notify or state that he carries on or is willing to carry on the business of a toxic industrial waste collector;</p>			

Annex B Singapore Regulations on Chemicals, Flammable or Hazardous Substances and Combustible Dusts

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(b) act as a toxic industrial waste collector; or</p> <p>(c) in any way hold himself out as ready to undertake for payment or other remuneration (whether monetary or otherwise) any of the functions of a toxic industrial waste collector, unless he is the holder of a toxic industrial waste collector's licence.</p>

Annex C SCDF Circular on Implementation of SS 667: 2020 – Code of Practice for Handling, Storage and Processing of combustible dust



Date: 1 June 2021

Our Ref: CD/HAZ/13/02/03

Registrar, Board of Architects
Registrar, Professional Engineers Board
President, Singapore Institute of Architects
President, Institution of Engineers, Singapore
President, Association of Consulting Engineers, Singapore

Dear Sir/Mdm

IMPLEMENTATION OF SS 667 : 2020 – CODE OF PRACTICE FOR HANDLING, STORAGE AND PROCESSING OF COMBUSTIBLE DUST

The SS 667 : 2020 – Code of Practice for Handling, Storage and Processing of Combustible Dust was officially launched by Enterprise Singapore on 19 May 2021. This standard sets out the requirements and recommendations to help in the prevention of fires and explosions that could result from the ignition of suspended, fine solid particles within an enclosure or buildings handling such materials.

2. Please be informed that the standard shall be applicable to all building plans that are submitted to SCDF for approval from 01 December 2021. This grace period is given to the building industry to plan for any new building projects. Any proposed plans of fire safety works for new buildings / premises or alteration / alteration works to existing buildings / premises that are submitted to SCDF for approval on or after the effective date will be subjected to the new standard. Notwithstanding the above, SCDF has no objection to the immediate adoption of the standard.
3. Please convey the contents of this circular to members of your Institution/Association/ Board. The circular is also available in CORENET-e-Info: <http://www.corenet.gov.sg/einfo>.

Annex D US - Extracts from the Occupational Safety and Health Act of 1970 and related legislations

Extract of US's Act/Regulations
<p>Occupational Safety and Health Act of 1970 https://www.osha.gov/laws-regs/oshact/toc</p> <p>Section 5 - Duties</p> <p>(a) Each employer –</p> <ul style="list-style-type: none">(1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees;(2) shall comply with occupational safety and health standards promulgated under this Act.
<p>Subparts of Part 1910 of the Code of Federal Regulations – Occupational Safety and Health Standards https://www.osha.gov/laws-regs/regulations/standardnumber/1910</p> <p>Using 1910.212 - General requirements for all machines as an example:</p> <p>1910.212(a) Machine guarding.</p> <p>1910.212(a)(1) Types of guarding.</p> <p>One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips and sparks. Examples of guarding methods are-barrier guards, two-hand tripping devices, electronic safety devices, etc.</p> <p>1910.212(a)(2) General requirements for machine guards.</p>

Extract of US's Act/Regulations

Guards shall be affixed to the machine where possible and secured elsewhere if for any reason attachment to the machine is not possible. The guard shall be such that it does not offer an accident hazard in itself.

1910.212(a)(3) Point of operation guarding.

1910.212(a)(3)(i) Point of operation is the area on a machine where work is actually performed upon the material being processed.

1910.212(a)(3)(ii) The point of operation of machines whose operation exposes an employee to injury, shall be guarded. The guarding device shall be in conformity with any appropriate standards therefor, or, in the absence of applicable specific standards, shall be so designed and constructed as to prevent the operator from having any part of his body in the danger zone during the operating cycle.

1910.212(a)(3)(iii) Special handtools for placing and removing material shall be such as to permit easy handling of material without the operator placing a hand in the danger zone. Such tools shall not be in lieu of other guarding required by this section, but can only be used to supplement protection provided.

1910.212(a)(3)(iv) The following are some of the machines which usually require point of operation guarding:

1910.212(a)(3)(iv)(a) Guillotine cutters.

1910.212(a)(3)(iv)(b) Shears.

1910.212(a)(3)(iv)(c) Alligator shears.

1910.212(a)(3)(iv)(d) Power presses.

1910.212(a)(3)(iv)(e) Milling machines.

1910.212(a)(3)(iv)(f) Power saws.

1910.212(a)(3)(iv)(g) Jointers.

1910.212(a)(3)(iv)(h) Portable power tools.

1910.212(a)(3)(iv)(i) Forming rolls and calenders.

Annex E UK - Extracts from the Health and Safety at Work etc. Act 1974 and related legislations

Extract of UK's Act/Regulations

Health and Safety at Work etc. Act 1974

<https://www.legislation.gov.uk/ukpga/1974/37/contents>

Section 2 - General duties of employers to their employees.

(1) It shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees.

(2) Without prejudice to the generality of an employer's duty under the preceding subsection, the matters to which that duty extends include in particular—

(a) the provision and maintenance of plant and systems of work that are, so far as is reasonably practicable, safe and without risks to health;

(b) arrangements for ensuring, so far as is reasonably practicable, safety and absence of risks to health in connection with the use, handling, storage and transport of articles and substances;

(c) the provision of such information, instruction, training and supervision as is necessary to ensure, so far as is reasonably practicable, the health and safety at work of his employees;

(d) so far as is reasonably practicable as regards any place of work under the employer's control, the maintenance of it in a condition that is safe and without risks to health and the provision and maintenance of means of access to and egress from it that are safe and without such risks;

(e) the provision and maintenance of a working environment for his employees that is, so far as is reasonably practicable, safe, without risks to health, and adequate as regards facilities and arrangements for their welfare at work.

Section 6 - General duties of manufacturers etc. as regards articles and substances for use at work

(1) It shall be the duty of any person who designs, manufactures, imports or supplies any article for use at work or any article of fairground equipment—

(a) to ensure, so far as is reasonably practicable, that the article is so designed and constructed that it will be safe and without risks to health at all times when it is being set, used, cleaned or maintained by a person at work;

Extract of UK's Act/Regulations

(b) to carry out or arrange for the carrying out of such testing and examination as may be necessary for the performance of the duty imposed on him by the preceding paragraph;

(c) to take such steps as are necessary to secure that persons supplied by that person with the article are provided with adequate information about the use for which the article is designed or has been tested and about any conditions necessary to ensure that it will be safe and without risks to health at all such times as are mentioned in paragraph (a) above and when it is being dismantled or disposed of; and

(d) to take such steps as are necessary to secure, so far as is reasonably practicable, that persons so supplied are provided with all such revisions of information provided to them by virtue of the preceding paragraph as are necessary by reason of its becoming known that anything gives rise to a serious risk to health or safety.

(2) It shall be the duty of any person who undertakes the design or manufacture of any article for use at work or of any article of fairground equipment to carry out or arrange for the carrying out of any necessary research with a view to the discovery and, so far as is reasonably practicable, the elimination or minimisation of any risks to health or safety to which the design or article may give rise.

(3) It shall be the duty of any person who erects or installs any article for use at work in any premises where that article is to be used by persons at work or who erects or installs any article of fairground equipment to ensure, so far as is reasonably practicable, that nothing about the way in which the article is erected or installed makes it unsafe or a risk to health at any such time as is mentioned in paragraph (a) of subsection (1) or, as the case may be, in paragraph (a) of subsection (1) or (1A) above.

Provision and Use of Work Equipment Regulations 1998

<https://www.legislation.gov.uk/uksi/1998/2306/contents/made>

PART II – General

Suitability of work equipment

4.

(1) Every employer shall ensure that work equipment is so constructed or adapted as to be suitable for the purpose for which it is used or provided.

(2) In selecting work equipment, every employer shall have regard to the working conditions and to the risks to the health and safety of persons which exist in the premises or undertaking in which that work equipment is to be used and any additional risk posed by the use of that work equipment.

Extract of UK's Act/Regulations

(3) Every employer shall ensure that work equipment is used only for operations for which, and under conditions for which, it is suitable.

(4) In this regulation "suitable" means suitable in any respect which it is reasonably foreseeable will affect the health or safety of any person.

Maintenance

5.

(1) Every employer shall ensure that work equipment is maintained in an efficient state, in efficient working order and in good repair.

(2) Every employer shall ensure that where any machinery has a maintenance log, the log is kept up to date.

Inspection

6.

(1) Every employer shall ensure that, where the safety of work equipment depends on the installation conditions, it is inspected—

(a) after installation and before being put into service for the first time; or

(b) after assembly at a new site or in a new location,

to ensure that it has been installed correctly and is safe to operate.

(2) Every employer shall ensure that work equipment exposed to conditions causing deterioration which is liable to result in dangerous situations is inspected—

(a) at suitable intervals; and

(b) each time that exceptional circumstances which are liable to jeopardise the safety of the work equipment have occurred,

to ensure that health and safety conditions are maintained and that any deterioration can be detected and remedied in good time.

(3) Every employer shall ensure that the result of an inspection made under this regulation is recorded and kept until the next inspection under this regulation is recorded.

(4) Every employer shall ensure that no work equipment—

(a) leaves his undertaking; or

Extract of UK's Act/Regulations

(b) if obtained from the undertaking of another person, is used in his undertaking, unless it is accompanied by physical evidence that the last inspection required to be carried out under this regulation has been carried out.

(5) This regulation does not apply to—

- (a) a power press to which regulations 32 to 35 apply;
- (b) a guard or protection device for the tools of such power press;
- (c) work equipment for lifting loads including persons;
- (d) winding apparatus to which the Mines (Shafts and Winding) Regulations 1993(1) apply;
- (e) work equipment required to be inspected by regulation 29 of the Construction (Health, Safety and Welfare) Regulations 1996(2).

Specific risks

7.

(1) Where the use of work equipment is likely to involve a specific risk to health or safety, every employer shall ensure that—

- (a) the use of that work equipment is restricted to those persons given the task of using it; and
- (b) repairs, modifications, maintenance or servicing of that work equipment is restricted to those persons who have been specifically designated to perform operations of that description (whether or not also authorised to perform other operations).

(2) The employer shall ensure that the persons designated for the purposes of sub-paragraph (b) of paragraph (1) have received adequate training related to any operations in respect of which they have been so designated.

Information and instructions

8.

(1) Every employer shall ensure that all persons who use work equipment have available to them adequate health and safety information and, where appropriate, written instructions pertaining to the use of the work equipment.

(2) Every employer shall ensure that any of his employees who supervises or manages the use of work equipment has available to him adequate health and safety information and, where appropriate, written instructions pertaining to the use of the work equipment.

Extract of UK's Act/Regulations

(3) Without prejudice to the generality of paragraphs (1) or (2), the information and instructions required by either of those paragraphs shall include information and, where appropriate, written instructions on—

- (a) the conditions in which and the methods by which the work equipment may be used;
- (b) foreseeable abnormal situations and the action to be taken if such a situation were to occur; and
- (c) any conclusions to be drawn from experience in using the work equipment.

(4) Information and instructions required by this regulation shall be readily comprehensible to those concerned.

Training

9.

(1) Every employer shall ensure that all persons who use work equipment have received adequate training for purposes of health and safety, including training in the methods which may be adopted when using the work equipment, any risks which such use may entail and precautions to be taken.

(2) Every employer shall ensure that any of his employees who supervises or manages the use of work equipment has received adequate training for purposes of health and safety, including training in the methods which may be adopted when using the work equipment, any risks which such use may entail and precautions to be taken.

Dangerous parts of machinery

11.

(1) Every employer shall ensure that measures are taken in accordance with paragraph (2) which are effective—

- (a) to prevent access to any dangerous part of machinery or to any rotating stock-bar; or
- (b) to stop the movement of any dangerous part of machinery or rotating stock-bar before any part of a person enters a danger zone.

(2) The measures required by paragraph (1) shall consist of—

- (a) the provision of fixed guards enclosing every dangerous part or rotating stock-bar where and to the extent that it is practicable to do so, but where or to the extent that it is not, then
- (b) the provision of other guards or protection devices where and to the extent that it is practicable to do so, but where or to the extent that it is not, then

Extract of UK's Act/Regulations

(c) the provision of jigs, holders, push-sticks or similar protection appliances used in conjunction with the machinery where and to the extent that it is practicable to do so, but where or to the extent that it is not, then

(d) the provision of information, instruction, training and supervision.

(3) All guards and protection devices provided under sub-paragraphs (a) or (b) of paragraph (2) shall—

(a) be suitable for the purpose for which they are provided;

(b) be of good construction, sound material and adequate strength;

(c) be maintained in an efficient state, in efficient working order and in good repair;

(d) not give rise to any increased risk to health or safety;

(e) not be easily bypassed or disabled;

(f) be situated at sufficient distance from the danger zone;

(g) not unduly restrict the view of the operating cycle of the machinery, where such a view is necessary;

(h) be so constructed or adapted that they allow operations necessary to fit or replace parts and for maintenance work, restricting access so that it is allowed only to the area where the work is to be carried out and, if possible, without having to dismantle the guard or protection device.

(4) All protection appliances provided under sub-paragraph (c) of paragraph (2) shall comply with sub-paragraphs (a) to (d) and (g) of paragraph (3).

(5) In this regulation—

“danger zone” means any zone in or around machinery in which a person is exposed to a risk to health or safety from contact with a dangerous part of machinery or a rotating stock-bar; “stock-bar” means any part of a stock-bar which projects beyond the head-stock of a lathe.

Protection against specified hazards

12.

(1) Every employer shall take measures to ensure that the exposure of a person using work equipment to any risk to his health or safety from any hazard specified in paragraph (3) is either prevented, or, where that is not reasonably practicable, adequately controlled.

(2) The measures required by paragraph (1) shall—

Annex E UK - Extracts from the Health and Safety at Work etc. Act 1974 and related legislations

Extract of UK's Act/Regulations

(a) be measures other than the provision of personal protective equipment or of information, instruction, training and supervision, so far as is reasonably practicable; and

(b) include, where appropriate, measures to minimise the effects of the hazard as well as to reduce the likelihood of the hazard occurring.

(3) The hazards referred to in paragraph (1) are—

(a) any article or substance falling or being ejected from work equipment;

(b) rupture or disintegration of parts of work equipment;

(c) work equipment catching fire or overheating;

(d) the unintended or premature discharge of any article or of any gas, dust, liquid, vapour or other substance which, in each case, is produced, used or stored in the work equipment;

(e) the unintended or premature explosion of the work equipment or any article or substance produced, used or stored in it.

(4) For the purposes of this regulation “adequately” means adequately having regard only to the nature of the hazard and the nature and degree of exposure to the risk.

(5) This regulation shall not apply where any of the following Regulations apply in respect of any risk to a person’s health or safety for which such Regulations require measures to be taken to prevent or control such risk, namely—

(a) the Ionising Radiations Regulations 1985(3);

(b) the Control of Asbestos at Work Regulations 1987(4);

(c) the Control of Substances Hazardous to Health Regulations 1994(5);

(d) the Noise at Work Regulations 1989(6);

(e) the Construction (Head Protection) Regulations 1989(7);

(f) the Control of Lead at Work Regulations 1998(8).

Extract of UK's Act/Regulations

High or very low temperature

13. Every employer shall ensure that work equipment, parts of work equipment and any article or substance produced, used or stored in work equipment which, in each case, is at a high or very low temperature shall have protection where appropriate so as to prevent injury to any person by burn, scald or sear.

Controls for starting or making a significant change in operating conditions

14.

(1) Every employer shall ensure that, where appropriate, work equipment is provided with one or more controls for the purposes of—

(a) starting the work equipment (including re-starting after a stoppage for any reason); or

(b) controlling any change in the speed, pressure or other operating conditions of the work equipment where such conditions after the change result in risk to health and safety which is greater than or of a different nature from such risks before the change.

(2) Subject to paragraph (3), every employer shall ensure that, where a control is required by paragraph (1), it shall not be possible to perform any operation mentioned in sub-paragraph (a) or (b) of that paragraph except by a deliberate action on such control.

(3) Paragraph (1) shall not apply to re-starting or changing operating conditions as a result of the normal operating cycle of an automatic device.

Stop controls

15.

(1) Every employer shall ensure that, where appropriate, work equipment is provided with one or more readily accessible controls the operation of which will bring the work equipment to a safe condition in a safe manner.

(2) Any control required by paragraph (1) shall bring the work equipment to a complete stop where necessary for reasons of health and safety.

(3) Any control required by paragraph (1) shall, if necessary for reasons of health and safety, switch off all sources of energy after stopping the functioning of the work equipment.

(4) Any control required by paragraph (1) shall operate in priority to any control which starts or changes the operating conditions of the work equipment.

Extract of UK's Act/Regulations

Emergency stop controls

16.

(1) Every employer shall ensure that, where appropriate, work equipment is provided with one or more readily accessible emergency stop controls unless it is not necessary by reason of the nature of the hazards and the time taken for the work equipment to come to a complete stop as a result of the action of any control provided by virtue of regulation 15(1).

(2) Any control required by paragraph (1) shall operate in priority to any control required by regulation 15(1).

Controls

17.

(1) Every employer shall ensure that all controls for work equipment are clearly visible and identifiable, including by appropriate marking where necessary.

(2) Except where necessary, the employer shall ensure that no control for work equipment is in a position where any person operating the control is exposed to a risk to his health or safety.

(3) Every employer shall ensure where appropriate—

(a) that, so far as is reasonably practicable, the operator of any control is able to ensure from the position of that control that no person is in a place where he would be exposed to any risk to his health or safety as a result of the operation of that control, but where or to the extent that it is not reasonably practicable;

(b) that, so far as is reasonably practicable, systems of work are effective to ensure that, when work equipment is about to start, no person is in a place where he would be exposed to a risk to his health or safety as a result of the work equipment starting, but where neither of these is reasonably practicable;

(c) that an audible, visible or other suitable warning is given by virtue of regulation 24 whenever work equipment is about to start.

(4) Every employer shall take appropriate measures to ensure that any person who is in a place where he would be exposed to a risk to his health or safety as a result of the starting or stopping of work equipment has sufficient time and suitable means to avoid that risk.

Extract of UK's Act/Regulations

Control systems

18.

(1) Every employer shall—

- (a) ensure, so far as is reasonably practicable, that all control systems of work equipment are safe; and
- (b) are chosen making due allowance for the failures, faults and constraints to be expected in the planned circumstances of use.

(2) Without prejudice to the generality of paragraph (1), a control system shall not be safe unless—

- (a) its operation does not create any increased risk to health or safety;
- (b) it ensures, so far as is reasonably practicable, that any fault in or damage to any part of the control system or the loss of supply of any source of energy used by the work equipment cannot result in additional or increased risk to health or safety;
- (c) it does not impede the operation of any control required by regulation 15 or 16.

Isolation from sources of energy

19.

(1) Every employer shall ensure that where appropriate work equipment is provided with suitable means to isolate it from all its sources of energy.

(2) Without prejudice to the generality of paragraph (1), the means mentioned in that paragraph shall not be suitable unless they are clearly identifiable and readily accessible.

(3) Every employer shall take appropriate measures to ensure that re-connection of any energy source to work equipment does not expose any person using the work equipment to any risk to his health or safety.

Maintenance operations

22. Every employer shall take appropriate measures to ensure that work equipment is so constructed or adapted that, so far as is reasonably practicable, maintenance operations which involve a risk to health or safety can be carried out while the work equipment is shut down, or in other cases—

- (a) maintenance operations can be carried out without exposing the person carrying them out to a risk to his health or safety; or

Extract of UK's Act/Regulations

(b) appropriate measures can be taken for the protection of any person carrying out maintenance operations which involve a risk to his health or safety.

Markings

23. Every employer shall ensure that work equipment is marked in a clearly visible manner with any marking appropriate for reasons of health and safety.

Warnings

24.

(1) Every employer shall ensure that work equipment incorporates any warnings or warning devices which are appropriate for reasons of health and safety.

(2) Without prejudice to the generality of paragraph (1), warnings given by warning devices on work equipment shall not be appropriate unless they are unambiguous, easily perceived and easily understood.

Annex F Australia - Extracts from the Work Health and Safety Act 2011 and related legislations

Extract of Australia's Act/Regulations

Work Health and Safety Act 2011

<https://www.legislation.gov.au/Details/C2011A00137>

Part 2—Health and safety duties

Division 3—Further duties of persons conducting businesses or undertakings

21 Duty of persons conducting businesses or undertakings involving management or control of fixtures, fittings or plant at workplaces

(1) In this section, person with management or control of fixtures, fittings or plant at a workplace means a person conducting a business or undertaking to the extent that the business or undertaking involves the management or control of fixtures, fittings or plant, in whole or in part, at a workplace, but does not include:

- (a) the occupier of a residence, unless the residence is occupied for the purposes of, or as part of, the conduct of a business or undertaking; or
- (b) a prescribed person.

(2) The person with management or control of fixtures, fittings or plant at a workplace must ensure, so far as is reasonably practicable, that the fixtures, fittings and plant are without risks to the health and safety of any person.

22 Duties of persons conducting businesses or undertakings that design plant, substances or structures

(1) This section applies to a person (the designer) who conducts a business or undertaking that designs:

- (a) plant that is to be used, or could reasonably be expected to be used, as, or at, a workplace; or
- (b) a substance that is to be used, or could reasonably be expected to be used, at a workplace; or
- (c) a structure that is to be used, or could reasonably be expected to be used, as, or at, a workplace.

Extract of Australia's Act/Regulations

(2) The designer must ensure, so far as is reasonably practicable, that the plant, substance or structure is designed to be without risks to the health and safety of persons:

- (a) who, at a workplace, use the plant, substance or structure for a purpose for which it was designed; or
- (b) who handle the substance at a workplace; or
- (c) who store the plant or substance at a workplace; or
- (d) who construct the structure at a workplace; or
- (e) who carry out any reasonably foreseeable activity at a workplace in relation to:
 - (i) the manufacture, assembly or use of the plant for a purpose for which it was designed, or the proper storage, decommissioning, dismantling or disposal of the plant; or
 - (ii) the manufacture or use of the substance for a purpose for which it was designed or the proper handling, storage or disposal of the substance; or
 - (iii) the manufacture, assembly or use of the structure for a purpose for which it was designed or the proper demolition or disposal of the structure; or
- (f) who are at or in the vicinity of a workplace and who are exposed to the plant, substance or structure at the workplace or whose health or safety may be affected by a use or activity referred to in paragraph (a), (b), (c), (d) or (e).

(3) The designer must carry out, or arrange the carrying out of, any calculations, analysis, testing or examination that may be necessary for the performance of the duty imposed by subsection (2).

(4) The designer must give adequate information to each person who is provided with the design for the purpose of giving effect to it concerning:

- (a) each purpose for which the plant, substance or structure was designed; and
- (b) the results of any calculations, analysis, testing or examination referred to in subsection (3), including, in relation to a substance, any hazardous properties of the substance identified by testing; and
- (c) any conditions necessary to ensure that the plant, substance or structure is without risks to health and safety when used for a purpose for which it was designed or when carrying out any activity referred to in subsection (2)(a) to (e).

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(5) The designer, on request, must, so far as is reasonably practicable, give current relevant information on the matters referred to in subsection (4) to a person who carries out, or is to carry out, any of the activities referred to in subsection (2)(a) to (e).

23 Duties of persons conducting businesses or undertakings that manufacture plant, substances or structures

(1) This section applies to a person (the manufacturer) who conducts a business or undertaking that manufactures:

- (a) plant that is to be used, or could reasonably be expected to be used, as, or at, a workplace; or
- (b) a substance that is to be used, or could reasonably be expected to be used, at a workplace; or
- (c) a structure that is to be used, or could reasonably be expected to be used, as, or at, a workplace.

(2) The manufacturer must ensure, so far as is reasonably practicable, that the plant, substance or structure is manufactured to be without risks to the health and safety of persons:

- (a) who, at a workplace, use the plant, substance or structure for a purpose for which it was designed or manufactured; or
- (b) who handle the substance at a workplace; or
- (c) who store the plant or substance at a workplace; or
- (d) who construct the structure at a workplace; or
- (e) who carry out any reasonably foreseeable activity at a workplace in relation to:
 - (i) the assembly or use of the plant for a purpose for which it was designed or manufactured or the proper storage, decommissioning, dismantling or disposal of the plant; or
 - (ii) the use of the substance for a purpose for which it was designed or manufactured or the proper handling, storage or disposal of the substance; or
 - (iii) the assembly or use of the structure for a purpose for which it was designed or manufactured or the proper demolition or disposal of the structure; or

Extract of Australia's Act/Regulations

Example: Inspection, operation, cleaning, maintenance or repair of plant.

(f) who are at or in the vicinity of a workplace and who are exposed to the plant, substance or structure at the workplace or whose health or safety may be affected by a use or activity referred to in paragraph (a), (b), (c), (d) or (e).

(3) The manufacturer must carry out, or arrange the carrying out of, any calculations, analysis, testing or examination that may be necessary for the performance of the duty imposed by subsection (2).

(4) The manufacturer must give adequate information to each person to whom the manufacturer provides the plant, substance or structure concerning:

(a) each purpose for which the plant, substance or structure was designed or manufactured; and

(b) the results of any calculations, analysis, testing or examination referred to in subsection (3), including, in relation to a substance, any hazardous properties of the substance identified by testing; and

(c) any conditions necessary to ensure that the plant, substance or structure is without risks to health and safety when used for a purpose for which it was designed or manufactured or when carrying out any activity referred to in subsection (2)(a) to (e).

(5) The manufacturer, on request, must, so far as is reasonably practicable, give current relevant information on the matters referred to in subsection (4) to a person who carries out, or is to carry out, any of the activities referred to in subsection (2)(a) to (e).

24 Duties of persons conducting businesses or undertakings that import plant, substances or structures

(1) This section applies to a person (the importer) who conducts a business or undertaking that imports:

(a) plant that is to be used, or could reasonably be expected to be used, as, or at, a workplace; or

(b) a substance that is to be used, or could reasonably be expected to be used, at a workplace; or

(c) a structure that is to be used, or could reasonably be expected to be used, as, or at, a workplace.

(2) The importer must ensure, so far as is reasonably practicable, that the plant, substance or structure is without risks to the health and safety of persons:

(a) who, at a workplace, use the plant, substance or structure for a purpose for which it was designed or manufactured; or

Extract of Australia's Act/Regulations

- (b) who handle the substance at a workplace; or
- (c) who store the plant or substance at a workplace; or
- (d) who construct the structure at a workplace; or
- (e) who carry out any reasonably foreseeable activity at a workplace in relation to:
 - (i) the assembly or use of the plant for a purpose for which it was designed or manufactured or the proper storage, decommissioning, dismantling or disposal of the plant; or
 - (ii) the use of the substance for a purpose for which it was designed or manufactured or the proper handling, storage or disposal of the substance; or
 - (iii) the assembly or use of the structure for a purpose for which it was designed or manufactured or the proper demolition or disposal of the structure; or

Example: Inspection, operation, cleaning, maintenance or repair of plant.

- (f) who are at or in the vicinity of a workplace and who are exposed to the plant, substance or structure at the workplace or whose health or safety may be affected by a use or activity referred to in paragraph (a), (b), (c), (d) or (e).

(3) The importer must:

- (a) carry out, or arrange the carrying out of, any calculations, analysis, testing or examination that may be necessary for the performance of the duty imposed by subsection (2); or
- (b) ensure that the calculations, analysis, testing or examination have been carried out.

(4) The importer must give adequate information to each person to whom the importer provides the plant, substance or structure concerning:

- (a) each purpose for which the plant, substance or structure was designed or manufactured; and
- (b) the results of any calculations, analysis, testing or examination referred to in subsection (3), including, in relation to a substance, any hazardous properties of the substance identified by testing; and
- (c) any conditions necessary to ensure that the plant, substance or structure is without risks to health and safety when used for a purpose for which it was designed or manufactured or when carrying out any activity referred to in subsection (2)(a) to (e).

Extract of Australia's Act/Regulations

(5) The importer, on request, must, so far as is reasonably practicable, give current relevant information on the matters referred to in subsection (4) to a person who carries out, or is to carry out, any of the activities referred to in subsection (2)(a) to (e).

25 Duties of persons conducting businesses or undertakings that supply plant, substances or structures

(1) This section applies to a person (the supplier) who conducts a business or undertaking that supplies:

- (a) plant that is to be used, or could reasonably be expected to be used, as, or at, a workplace; or
- (b) a substance that is to be used, or could reasonably be expected to be used, at a workplace; or
- (c) a structure that is to be used, or could reasonably be expected to be used, as, or at, a workplace.

(2) The supplier must ensure, so far as is reasonably practicable, that the plant, substance or structure is without risks to the health and safety of persons:

- (a) who, at a workplace, use the plant or substance or structure for a purpose for which it was designed or manufactured; or
- (b) who handle the substance at a workplace; or
- (c) who store the plant or substance at a workplace; or
- (d) who construct the structure at a workplace; or
- (e) who carry out any reasonably foreseeable activity at a workplace in relation to:
 - (i) the assembly or use of the plant for a purpose for which it was designed or manufactured or the proper storage, decommissioning, dismantling or disposal of the plant; or
 - (ii) the use of the substance for a purpose for which it was designed or manufactured or the proper handling, storage or disposal of the substance; or
 - (iii) the assembly or use of the structure for a purpose for which it was designed or manufactured or the proper demolition or disposal of the structure; or

Extract of Australia's Act/Regulations

(f) who are at or in the vicinity of a workplace and who are exposed to the plant, substance or structure at the workplace or whose health or safety may be affected by a use or activity referred to in paragraph (a), (b), (c), (d) or (e).

(3) The supplier must:

(a) carry out, or arrange the carrying out of, any calculations, analysis, testing or examination that may be necessary for the performance of the duty imposed by subsection (2); or

(b) ensure that the calculations, analysis, testing or examination have been carried out.

(4) The supplier must give adequate information to each person to whom the supplier supplies the plant, substance or structure concerning:

(a) each purpose for which the plant, substance or structure was designed or manufactured; and

(b) the results of any calculations, analysis, testing or examination referred to in subsection (3), including, in relation to a substance, any hazardous properties of the substance identified by testing; and

(c) any conditions necessary to ensure that the plant, substance or structure is without risks to health and safety when used for a purpose for which it was designed or manufactured or when carrying out any activity referred to in subsection (2)(a) to (e).

(5) The supplier, on request, must, so far as is reasonably practicable, give current relevant information on the matters referred to in subsection (4) to a person who carries out, or is to carry out, any of the activities referred to in subsection (2)(a) to (e).

26 Duty of persons conducting businesses or undertakings that install, construct or commission plant or structures

(1) This section applies to a person who conducts a business or undertaking that installs, constructs or commissions plant or a structure that is to be used, or could reasonably be expected to be used, as, or at, a workplace.

(2) The person must ensure, so far as is reasonably practicable, that the way in which the plant or structure is installed, constructed or commissioned ensures that the plant or structure is without risks to the health and safety of persons:

(a) who install or construct the plant or structure at a workplace; or

(b) who use the plant or structure at a workplace for a purpose for which it was installed, constructed or commissioned; or

Extract of Australia's Act/Regulations
<p>(c) who carry out any reasonably foreseeable activity at a workplace in relation to the proper use, decommissioning or dismantling of the plant or demolition or disposal of the structure; or</p> <p>(d) who are at or in the vicinity of a workplace and whose health or safety may be affected by a use or activity referred to in paragraph (a), (b) or (c).</p>
<p>Work Health and Safety Regulations 2011 https://www.legislation.gov.au/Details/F2020C00693</p> <p>Chapter 5—Plant and structures Part 5.1—General duties for plant and structures</p> <p>Division 2—Duties of persons conducting businesses or undertakings that design plant</p> <p>187 Provision of information to manufacturer</p> <p>A designer of plant must ensure, when the design of the plant is made available to the manufacturer of the plant, that the manufacturer is provided with:</p> <ul style="list-style-type: none">(a) information to enable the plant to be manufactured in accordance with the design specifications; and(b) if applicable, information about:<ul style="list-style-type: none">(i) the installation, commissioning, decommissioning, use, handling, storage and, if the plant is capable of being dismantled, dismantling of the plant; and(ii) the hazards and risks associated with the use of the plant that the designer has identified; and(iii) testing or inspections to be carried out on the plant; and(iv) the systems of work and competency of operators that are necessary for the safe use of the plant; and(v) the emergency procedures (if any) that are required to be implemented if there is a malfunction of the plant.

Extract of Australia's Act/Regulations

188 Hazard identified in design during manufacture

If a manufacturer of plant advises the designer of the plant that there is a hazard in the design of plant for which the designer has not provided a control measure, the designer must:

- (a) revise the information originally supplied to the manufacturer to ensure that:
 - (i) the risk is eliminated so far as is reasonably practicable; or
 - (ii) if it is not reasonably practicable to eliminate the risk, the risk is minimised so far as is reasonably practicable; or
- (b) notify the manufacturer, in writing, that the designer is of the opinion that it is not necessary to revise the information originally supplied to the manufacturer to ensure compliance with this Part.

189 Guarding

(1) This regulation applies if a designer of plant uses guarding as a measure to control risk.

(2) The designer must ensure, so far as is reasonably practicable, that the guarding designed for that purpose will prevent access to the danger point or danger area of the plant.

(3) The designer must ensure that:

- (a) if access to the area of the plant requiring guarding is not necessary during operation, maintenance or cleaning of the plant—the guarding is a permanently fixed physical barrier; or
- (b) if access to the area of the plant requiring guarding is necessary during operation, maintenance or cleaning of the plant—the guarding is an interlocked physical barrier that allows access to the area being guarded at times when that area does not present a risk and prevents access to that area at any other time; or
- (c) if it is not reasonably practicable to use guarding referred to in paragraph (a) or (b)—the guarding used is a physical barrier that can only be altered or removed by the use of tools; or

Extract of Australia's Act/Regulations

(d) if it is not reasonably practicable to use guarding referred to in paragraph (a), (b) or (c)—the design includes a presence-sensing safeguarding system that eliminates any risk arising from the area of the plant requiring guarding while a person or any part of a person is in the area being guarded.

(4) The designer must ensure that the guarding is designed:

- (a) to be of solid construction and securely mounted so as to resist impact or shock; and
- (b) to make bypassing or disabling of the guarding, whether deliberately or by accident, as difficult as is reasonably practicable; and
- (c) so as not to cause a risk in itself.

(5) If the plant to be guarded contains moving parts and those parts may break or cause workpieces to be ejected from the plant, the designer must ensure, so far as is reasonably practicable, that the guarding will control any risk from those broken or ejected parts and workpieces.

(6) Despite anything to the contrary in this regulation, the designer must ensure:

- (a) that the guarding is of a kind that can be removed to allow maintenance and cleaning of the plant at any time that the plant is not in normal operation; and
- (b) if the guarding is removed, that, so far as is reasonably practicable, the plant cannot be restarted unless the guarding is replaced.

190 Operational controls

(1) A designer of plant must ensure that the design provides for any operator's controls for the plant to be:

- (a) identified on the plant so as to indicate their nature and function and direction of operation; and
- (b) located so as to be readily and conveniently operated by each person using the plant; and
- (c) located or guarded to prevent unintentional activation; and
- (d) able to be locked into the 'off' position to enable the disconnection of all motive power.

Extract of Australia's Act/Regulations

(2) If the need for plant to be operated during maintenance or cleaning cannot be eliminated, the designer of the plant must ensure that the design provides for operator's controls that:

- (a) permit operation of the plant while a person is undertaking the maintenance or cleaning of the plant; and
- (b) while the plant is being maintained or cleaned, cannot be operated by any person other than the person who is carrying out the maintenance or cleaning of the plant; and
- (c) will allow operation of the plant in such a way that any risk associated with the activities in relation to any person who is carrying out the maintenance or cleaning:
 - (i) is eliminated so far as is reasonably practicable; or
 - (ii) if it is not reasonably practicable to eliminate the risk, is minimised so far as is reasonably practicable.

191 Emergency stop controls

(1) If plant is designed to be operated or attended by more than one person and more than one emergency stop control is fitted, the designer of the plant must ensure that the design provides for the multiple emergency stop controls to be of the 'stop and lock-off' type so that the plant cannot be restarted after an emergency stop control has been used unless that emergency stop control is reset.

(2) If the design of the plant includes an emergency stop control for the plant, the designer of the plant must ensure that the design provides:

- (a) for the stop control to be prominent, clearly and durably marked and immediately accessible to each operator of the plant; and
- (b) for any handle, bar or push button associated with the stop control to be coloured red; and
- (c) that the stop control cannot be adversely affected by electrical or electronic circuit malfunction.

192 Warning devices

(1) This regulation applies if the design of plant includes an emergency warning device or it is necessary to include an emergency warning device to minimise risk.

Extract of Australia's Act/Regulations

(2) The designer of the plant must ensure that the design provides for the device to be positioned on the plant to ensure the device will work to best effect.

Division 3—Duties of persons conducting businesses or undertakings that manufacture plant

193 Control of risk

(1) A manufacturer of plant must ensure the following:

- (a) that the plant is manufactured and inspected having regard to the information provided to the manufacturer by the designer of the plant under the Act and these Regulations;
- (b) if the information provided to the manufacturer by the designer of the plant under the Act and these Regulations requires the plant to be tested—that the plant is tested in accordance with that information;
- (c) if, during the manufacturing process, any hazard is identified in the design of the plant for which the designer has not provided a control measure:
 - (i) that the hazard is not incorporated into the manufacture of the plant; and
 - (ii) that the designer of the plant is given written notice of the hazard as soon as practicable; and
 - (iii) that all reasonable steps are taken to consult with the designer of the plant in relation to the alteration of the design to rectify the hazard.

(2) A manufacturer of plant must ensure that, if it is not possible to notify the designer of the hazard in accordance with subregulation (1):

- (a) the risk is eliminated, so far as is reasonably practicable; or
- (b) if it is not reasonably practicable to eliminate the risk, the risk is minimised so far as is reasonably practicable.

Note: WHS Act—section 23 (see regulation 9).

(3) A manufacturer to whom paragraph (1)(c) applies must not manufacture the plant until:

- (a) the designer gives the manufacturer the revised information or written instruction under regulation 188; or

Extract of Australia's Act/Regulations

(b) the manufacturer eliminates or minimises the risk under subregulation (2).

Note: WHS Act—section 23 (see regulation 9).

(4) If the designer notifies a manufacturer of plant under regulation 188, the manufacturer may proceed in accordance with the designer's original information.

194 Guarding

(1) A manufacturer of plant must ensure that guarding used as a control measure is of solid construction and securely mounted so as to resist impact or shock.

(2) A manufacturer of plant must ensure:

(a) that any guarding used as a control measure in relation to plant is of a kind that can be removed to allow maintenance and cleaning of the plant at any time that the plant is not in normal operation; and

(b) if the guarding is removed—that, so far as is reasonably practicable, the plant cannot be restarted unless the guarding is replaced.

195 Information must be obtained and provided

A manufacturer of plant must:

(a) take all reasonable steps to obtain the information required to be provided to the manufacturer by the designer of the plant under paragraphs 22(4)(a) and (c) of the Act and regulations 187 and 188; and

(b) ensure that a person to whom the manufacturer supplies the plant is, at the time of supply, provided with the information provided to the manufacturer by the designer under paragraphs 22(4)(a) and (c) of the Act and regulation 187; and

(c) if the manufacturer acts in accordance with regulation 193(1)(c), ensure that a person to whom the manufacturer supplies the plant is provided with the information, applicable to the plant, that is required to be provided by the designer under sections 22(4)(a) and (c) of the Act and regulation 188.

Extract of Australia's Act/Regulations

Division 4—Duties of persons conducting businesses or undertakings that import plant

196 Information to be obtained and provided by importer

An importer of plant must:

- (a) take all reasonable steps to obtain:
 - (i) the information that would be required to be provided by a manufacturer under paragraphs 23(4)(a) and (c) of the Act; and
 - (ii) the information that would be required to be provided by the designer of the plant to the manufacturer under regulations 187 and 188; and
- (b) give that information to any person to whom the importer supplies the plant.

197 Control of risk

An importer of plant must:

- (a) ensure that the plant is inspected having regard to the information provided by the manufacturer; and
- (b) if the information provided by the manufacturer requires the plant to be tested—ensure that the plant is tested in accordance with that information; and
- (c) if any hazards are identified:
 - (i) ensure that the plant is not supplied until the risks have been eliminated so far as is reasonably practicable; and
 - (ii) if it is not reasonably practicable to eliminate the risks, advise the person to whom the plant is supplied of the risks; and
- (d) take all reasonable steps to ensure that the designer and manufacturer of the plant are consulted in relation to any alteration made to the plant to control the risk.

Extract of Australia's Act/Regulations

Division 5—Duties of persons conducting businesses or undertakings that supply plant

198 Information to be obtained and provided by supplier

A supplier of plant must:

- (a) take all reasonable steps to obtain the information required to be provided by the manufacturer under paragraphs 23(4)(a) and (c) of the Act and these Regulations; and
- (b) ensure that, when the plant is supplied, the person to whom the plant is supplied is given the information obtained by the supplier under paragraph (a).

199 Supply of second-hand plant—duties of supplier

- (1) A supplier of second-hand plant must ensure, so far as is reasonably practicable, that any faults in the plant are identified.
- (2) A supplier of second-hand plant must ensure that the person to whom the plant is supplied is, before the plant is supplied, given written notice:
 - (a) of the condition of the plant; and
 - (b) of any faults identified under subregulation (1); and
 - (c) if appropriate, that the plant should not be used until the faults are rectified.
- (3) This regulation does not apply to plant to be used for scrap or spare parts.

200 Second-hand plant to be used for scrap or spare parts

A supplier of plant to be used for scrap or spare parts must, before the plant is supplied, inform the person to whom the plant is supplied, either in writing or by marking the plant, that the plant is being supplied for scrap or spare parts and that the plant in its current form is not to be used as plant.

Extract of Australia's Act/Regulations

Division 6—Duties of persons conducting businesses or undertakings that install, construct or commission plant

201 Duties of persons conducting businesses or undertakings that install, construct or commission plant

(1) This regulation applies to a person who conducts a business or undertaking that installs, constructs or commissions plant that is to be used, or could reasonably be expected to be used, as, or at, a workplace.

(2) The person must ensure that the plant is installed, constructed or commissioned having regard to:

- (a) the information provided by the designer, manufacturer, importer or supplier of the plant under the Act and these Regulations; or
- (b) the instructions provided by a competent person to the extent that those instructions relate to health and safety.

202 Duties of persons conducting businesses or undertakings that install, construct or commission structures

(1) This regulation applies to a person who conducts a business or undertaking that installs, constructs or commissions a structure that is to be used, or could reasonably be expected to be used, as or at, a workplace.

(2) The person must ensure that the structure is installed, constructed or commissioned having regard to:

- (a) the information provided by the designer, manufacturer, importer or supplier of the structure under the Act and these Regulations; or
- (b) the instructions provided by a competent person to the extent that those instructions relate to health and safety.

Division 7—General duties of persons conducting a business or undertaking involving the management or control of plant

Note: A person with management or control of plant at a workplace is the person conducting a business or undertaking at the workplace to the extent that the business or undertaking involves the management or control of plant in whole or in part at the workplace. See the definition of person with management or control of plant at a workplace in subregulation 5(1) and section 21 of the Act.

Subdivision 1—Management of risks

203 Management of risks to health and safety

Extract of Australia's Act/Regulations

A person with management or control of plant at a workplace must manage risks to health and safety associated with plant, in accordance with Part 3.1.

Note: WHS Act—section 21 (see regulation 9).

Subdivision 2—Additional control measures for general plant

204 Control of risks arising from installation or commissioning

- (1) A person with management or control of plant at a workplace must not commission the plant unless the person has established that the plant is, so far as is reasonably practicable, without risks to the health and safety of any person.
- (2) A person with management or control of plant at a workplace must not decommission or dismantle the plant unless the decommissioning or dismantling can be carried out, so far as is reasonably practicable, without risks to the health and safety of any person.
- (3) A person with management or control of plant at a workplace must ensure that a person who installs, assembles, constructs, commissions or decommissions or dismantles the plant is a competent person.
- (4) A person with management or control of plant at a workplace must ensure that a person who installs, assembles, constructs, commissions or decommissions or dismantles the plant is provided with the available information for eliminating or minimising risks to health or safety.
- (5) A person with management or control of plant at a workplace must ensure that the processes for the installation, construction, commissioning, decommissioning and dismantling of plant include inspections that ensure, so far as is reasonably practicable, that risks associated with these activities are monitored.

205 Preventing unauthorised alterations to or interference with plant

The person with management or control of plant at a workplace must, so far as is reasonably practicable, prevent alterations to or interference with the plant that are not authorised by the person.

206 Proper use of plant and controls

Extract of Australia's Act/Regulations

- (1) The person with management or control of plant at a workplace must take all reasonable steps to ensure that plant is used only for the purpose for which it was designed, unless the person has determined that the proposed use does not increase the risk to health or safety.
- (2) In determining whether or not a proposed use of plant increases the risk to health or safety, the person with management or control of the plant must ensure that the risk associated with the proposed use is assessed by a competent person.
- (3) The person with management or control of plant at a workplace must take all reasonable steps to ensure that all health and safety features and warning devices (including guarding, operational controls, emergency stops and warning devices) are used in accordance with the instructions and information provided by that person under regulation 39.

207 Plant not in use

The person with management or control of plant at a workplace must ensure, so far as is reasonably practicable, that plant that is not in use is left in a state that does not create a risk to the health or safety of any person.

208 Guarding

- (1) This regulation applies if guarding is used as a control measure in relation to plant at a workplace.
- (2) The person with management or control of the plant must ensure that:
 - (a) if access to the area of the plant requiring guarding is not necessary during operation, maintenance or cleaning of the plant, the guarding is a permanently fixed physical barrier; or
 - (b) if access to the area of the plant requiring guarding is necessary during operation, maintenance or cleaning of the plant, the guarding is an interlocked physical barrier that allows access to the area being guarded at times when that area does not present a risk and prevents access to that area at any other time; or
 - (c) if it is not reasonably practicable to use guarding referred to in paragraph (a) or (b), the guarding used is a physical barrier that can only be altered or removed by the use of tools; or

Extract of Australia's Act/Regulations

(d) if it is not reasonably practicable to use guarding referred to in paragraph (a), (b) or (c), the guarding includes a presence-sensing safeguarding system that eliminates any risk arising from the area of the plant requiring guarding while a person or any part of a person is in the area being guarded.

(3) The person with management or control of the plant must ensure that the guarding:

- (a) is of solid construction and securely mounted so as to resist impact or shock; and
- (b) makes bypassing or disabling of the guarding, whether deliberately or by accident, as difficult as is reasonably practicable; and
- (c) does not create a risk in itself; and
- (d) is properly maintained.

(4) If the plant to be guarded contains moving parts that may break or cause workpieces to be ejected from the plant, the person with management or control of the plant must ensure, so far as is reasonably practicable, that the guarding will control any risk from those broken or ejected parts and workpieces.

(5) Despite anything to the contrary in this regulation, the person with management or control of the plant must ensure:

- (a) that the guarding is of a kind that can be removed to allow maintenance and cleaning of the plant at any time that the plant is not in normal operation; and
- (b) if guarding is removed, that, so far as is reasonably practicable, the plant cannot be restarted unless the guarding is replaced.

209 Guarding and insulation from heat and cold

The person with management or control of plant at a workplace must ensure, so far as is reasonably practicable, that any pipe or other part of the plant associated with heat or cold is guarded or insulated so that the plant is without risks to the health and safety of any person.

210 Operational controls

(1) The person with management or control of plant at a workplace must ensure that any operator's controls are:

- (a) identified on the plant so as to indicate their nature and function and direction of operation; and

Extract of Australia's Act/Regulations

- (b) located so as to be readily and conveniently operated by each person using the plant; and
- (c) located or guarded to prevent unintentional activation; and
- (d) able to be locked into the 'off' position to enable the disconnection of all motive power.

(2) If the need for plant to be operated during maintenance or cleaning cannot be eliminated, the person with management or control of the plant at a workplace must ensure that the operator's controls:

- (a) permit operation of the plant while a person is undertaking the maintenance or cleaning of the plant; and
- (b) while the plant is being maintained or cleaned, either:
 - (i) cannot be operated by any person other than the person who is carrying out the maintenance or cleaning of the plant; or
 - (ii) if subparagraph (i) cannot be complied with because the plant must be operated by a person other than the person who is carrying out the maintenance or cleaning of the plant, cannot be operated except by a person authorised by the person with management or control of the plant for that purpose; and
- (c) will allow operation of the plant in such a way that any risk associated with the activities in relation to any person who is carrying out the maintenance or cleaning:
 - (i) is eliminated so far as is reasonably practicable; or
 - (ii) if it is not reasonably practicable to eliminate the risk, is minimised so far as is reasonably practicable.

211 Emergency stops

- (1) If plant at a workplace is designed to be operated or attended by more than one person and more than one emergency stop control is fitted, the person with management or control of plant at the workplace must ensure that the multiple emergency stop controls are of the 'stop and lock-off' type so that the plant cannot be restarted after an emergency stop control has been used unless that emergency stop control is reset.
- (2) If the design of plant at a workplace includes an emergency stop control, the person with management or control of the plant at the workplace must ensure that:
 - (a) the stop control is prominent, clearly and durably marked and immediately accessible to each operator of the plant; and

Extract of Australia's Act/Regulations

- (b) any handle, bar or push button associated with the stop control is coloured red; and
- (c) the stop control cannot be adversely affected by electrical or electronic circuit malfunction.

212 Warning devices

- (1) This regulation applies if the design of plant includes an emergency warning device or it is necessary to include an emergency warning device to minimise risk.
- (2) The person with management or control of the plant must ensure that the device is positioned on the plant to ensure that the device will work to best effect.

213 Maintenance and inspection of plant

- (1) The person with management or control of plant at a workplace must ensure that the maintenance, inspection and, if necessary, testing of the plant is carried out by a competent person.
- (2) The maintenance, inspection and testing must be carried out:
 - (a) in accordance with the manufacturer's recommendations, if any; or
 - (b) if there are no manufacturer's recommendations, in accordance with the recommendations of a competent person; or
 - (c) in relation to inspection, if it is not reasonably practicable to comply with paragraph (a) or (b), annually.

Annex G Singapore - Extracts from the Workplace Safety and Health Act and related legislations

Extract of Singapore's Act/Regulations
<p>Workplace Safety and Health Act</p> <p>https://sso.agc.gov.sg/Act/WSHA2006</p> <p>Duty of occupier of workplace</p> <p>11. It shall be the duty of every occupier of any workplace to take, so far as is reasonably practicable, such measures to ensure that —</p> <ul style="list-style-type: none">(a) the workplace;(b) all means of access to or egress from the workplace; and(c) any machinery, equipment, plant, article or substance kept on the workplace, <p>are safe and without risks to health to every person within those premises, whether or not the person is at work or is an employee of the occupier.</p> <p>Duties of employers</p> <p>12.</p> <p>(1) It shall be the duty of every employer to take, so far as is reasonably practicable, such measures as are necessary to ensure the safety and health of his employees at work.</p> <p>(2) It shall be the duty of every employer to take, so far as is reasonably practicable, such measures as are necessary to ensure the safety and health of persons (not being his employees) who may be affected by any undertaking carried on by him in the workplace.</p> <p>(3) For the purposes of subsection (1), the measures necessary to ensure the safety and health of persons at work include —</p> <ul style="list-style-type: none">(a) providing and maintaining for those persons a work environment which is safe, without risk to health, and adequate as regards facilities and arrangements for their welfare at work;(b) ensuring that adequate safety measures are taken in respect of any machinery, equipment, plant, article or process used by those persons;

Extract of Singapore's Act/Regulations

(c) ensuring that those persons are not exposed to hazards arising out of the arrangement, disposal, manipulation, organisation, processing, storage, transport, working or use of things —

(i) in their workplace; or

(ii) near their workplace and under the control of the employer;

(d) developing and implementing procedures for dealing with emergencies that may arise while those persons are at work; and

(e) ensuring that those persons at work have adequate instruction, information, training and supervision as is necessary for them to perform their work.

(4) Every employer shall, where required by the regulations, give to persons (not being his employees) the prescribed information about such aspects of the way in which he conducts his undertaking as might affect their safety or health while those persons are at his workplace.

Duties of principals

14.

(1) Subject to subsection (2), it shall be the duty of every principal to take, so far as is reasonably practicable, such measures as are necessary to ensure the safety and health of —

(a) any contractor engaged by the principal when at work;

(b) any direct or indirect subcontractor engaged by such contractor when at work; and

(c) any employee employed by such contractor or subcontractor when at work.

(2) The duty imposed on the principal in subsection (1) shall only apply where the contractor, subcontractor or employee referred to in that subsection is working under the direction of the principal as to the manner in which the work is carried out.

(3) It shall be the duty of every principal to take, so far as is reasonably practicable, such measures as are necessary to ensure the safety and health of persons (other than a person referred to in subsection (1)(a), (b) or (c) working under the principal's direction) who may be affected by any undertaking carried on by him in the workplace.

(4) For the purposes of subsection (1), the measures necessary to ensure the safety and health of persons at work include —

Extract of Singapore's Act/Regulations

- (a) providing and maintaining for those persons a work environment which is safe, without risk to health, and adequate as regards facilities and arrangements for their welfare at work;
- (b) ensuring that adequate safety measures are taken in respect of any machinery, equipment, plant, article or process used by those persons;
- (c) ensuring that those persons are not exposed to hazards arising out of the arrangement, disposal, manipulation, organisation, processing, storage, transport, working or use of things —
 - (i) in their workplace; or
 - (ii) near their workplace and under the control of the principal;
- (d) developing and implementing procedures for dealing with emergencies that may arise while those persons are at work; and
- (e) ensuring that those persons at work have adequate instruction, information, training and supervision as is necessary for them to perform their work.

(5) Every principal shall, where required by the regulations, give to persons (other than a person referred to in subsection (1)(a), (b) or (c) working under the principal's direction) the prescribed information about such aspects of the way in which he conducts his undertaking as might affect their safety or health while those persons are at his workplace.

Duties of manufacturers and suppliers of machinery, equipment or hazardous substances used at work

16.

(1) Subject to this section, it shall be the duty of any person who manufactures or supplies any machinery, equipment or hazardous substance for use at work to ensure, so far as is reasonably practicable —

- (a) that the following information about the safe use of the machinery, equipment or hazardous substance is available to any person to whom the machinery, equipment or hazardous substance is supplied for use at work:
 - (i) the precautions (if any) to be taken for the proper use and maintenance of the machinery, equipment or hazardous substance;
 - (ii) the health hazards (if any) associated with the machinery, equipment or hazardous substance; and

Extract of Singapore's Act/Regulations

(iii) the information relating to and the results of any examinations or tests of the machinery, equipment or hazardous substance under paragraph (c) that are relevant to its safe use;

(b) that the machinery, equipment or hazardous substance is safe, and without risk to health, when properly used;

(c) that the machinery, equipment or hazardous substance is examined and tested so as to comply with the obligation imposed by paragraph (b).

(2) The duties imposed on any person specified in subsection (1) shall —

(a) apply only if the machinery, equipment or hazardous substance is manufactured or supplied in the course of trade, business, profession or undertaking carried on by the person, whether for profit or not;

(b) apply whether or not the machinery, equipment or hazardous substance is exclusively manufactured or supplied for use by persons at work; and

(c) extend to the supply of the machinery, equipment or hazardous substance by way of sale, transfer, lease or hire and whether as principal or agent, and to the supply of the machinery, equipment or hazardous substance to a person for the purpose of supply to others.

(3) The duties imposed on any person specified in subsection (1) shall not apply to a person by reason only that the person supplies the machinery or equipment under a hire-purchase agreement, conditional sale agreement or credit-sale agreement to another (referred to in this section as the customer) in the course of a business of financing the acquisition of the machinery or equipment by the customer from others.

(4) Where a person (referred to in this subsection as the ostensible supplier) supplies any machinery or equipment for use at work to a customer under a hire-purchase agreement, conditional sale agreement or credit-sale agreement, and the ostensible supplier —

(a) carries on the business of financing the acquisition of goods by others by means of such agreements; and

(b) in the course of that business acquired his interest in the machinery or equipment supplied to the customer as a means of financing its acquisition by the customer from a third person (referred to in this subsection as the effective supplier),

the effective supplier shall be treated for the purposes of this section as supplying the machinery or equipment to the customer instead of the ostensible supplier, and any duty imposed by subsection (1) on a supplier shall accordingly apply to the effective supplier, and not to the ostensible supplier.

(5) Where a person designs, manufactures or supplies any machinery, equipment or hazardous substance for use at work and does so for or to another on the basis of a written undertaking by that other to take specified steps sufficient to ensure, so far as is reasonably practicable, that the machinery,

Extract of Singapore's Act/Regulations

equipment or hazardous substance will be safe and without risk to health when properly used, the undertaking shall have the effect of relieving the first-mentioned person from the duty imposed by subsection (1)(b) to such extent as is reasonable having regard to the terms of the undertaking.

(6) Any person required under subsection (1)(c) to ensure that any machinery, equipment or hazardous substance is examined and tested so as to comply with the obligation imposed by subsection (1)(b) shall be regarded as having complied with subsection (1)(c) to the extent that —

- (a) the examination or test has already been carried out otherwise than by, or on behalf of, the person; and
- (b) it is reasonable for the person to rely on that examination or test.

(7) For the purposes of this section, an absence of safety, or a risk to health, shall be disregarded in so far as the case in or in relation to which it would arise is shown to be one the occurrence of which could not reasonably be foreseen.

(8) In this section, “supplier”, in relation to any machinery, equipment or hazardous substance, does not include a manufacturer of those items when supplying, but includes an importer when supplying those items.

(9) This section shall apply only to machinery, equipment or hazardous substances specified in the Fifth Schedule.

Duties of persons who erect, install or modify machinery or equipment and persons in control of machinery for use at work

17.

(1) It shall be the duty of any person who erects, installs or modifies any machinery or equipment for use at work to ensure, so far as is reasonably practicable, that the machinery or equipment is erected, installed or modified in such a manner that it is safe, and without risk to health, when properly used.

(2) The duty imposed on a person erecting, installing or modifying any machinery or equipment under subsection (1) shall apply only if the machinery or equipment is erected, installed or modified in the course of the person's trade, business, profession or undertaking.

(3) Any person required under subsection (1) to ensure that any machinery or equipment is erected, installed or modified in such a manner that it is safe, and without risk to health, when properly used shall be regarded as having complied with that subsection to the extent that —

- (a) the person ensured, so far as is reasonably practicable, that the erection, installation or modification was in accordance with the information supplied by the designer, manufacturer or supplier of the machinery or equipment regarding its erection, installation or modification; and

Extract of Singapore's Act/Regulations

(b) it is reasonable for the person to rely on that information.

(4) Where any machinery moved by mechanical power is used in any workplace, then notwithstanding anything in this Act, it shall be the duty of the owner of the machinery to ensure —

(a) so far as is reasonably practicable, that the machinery is maintained in a safe condition; and

(b) that the precautions (if any) to be taken for the safe use of the machinery and the health hazards (if any) associated with the machinery are available to any person using the machinery.

(5) Where the owner of any machinery moved by mechanical power has entered into a contract of hire or lease with a hirer or lessee, the duty imposed under subsection (4) shall apply to the hirer or lessee of the machinery instead of the owner.

(6) Where the owner, hirer or lessee of any machinery moved by mechanical power has entered into a contract with another person to maintain the machinery, the duty under subsection (4)(a) shall apply to that other person instead of the owner, hirer or lessee of the machinery.

(7) Subsections (1), (2) and (3) shall apply only to machinery or equipment specified in Part I of the Fifth Schedule.

FIFTH SCHEDULE - MACHINERY, EQUIPMENT OR HAZARDOUS SUBSTANCES

PART I - MACHINERY AND EQUIPMENT

1. Scaffolds and any materials or components used to erect them
2. All lifting equipment
3. Forklifts
4. Power presses
5. Bar-benders
6. Any equipment or piping intended for operation under pressure, including all statutory pressure vessels
7. Any equipment or piping intended to contain corrosive, toxic or flammable substances
8. Welding equipment, including any accessory, apparatus or fitting necessary to enable its use
9. Materials or components used for the construction of support structures

Extract of Singapore's Act/Regulations

10. Explosive powered tools

11. Equipment used for abrasive blasting, including any accessory, apparatus or fitting necessary to enable its use and operation.

Workplace Safety and Health (General Provisions) Regulations

<https://sso.agc.gov.sg/SL/354A-RG1?DocDate=20110909>

Part III – General Provisions Relating to Safety

Hoists and lifts

19.

(1) No hoist or lift shall be used in a workplace unless an authorised examiner has —

- (a) tested and examined the hoist or lift after its installation; and
- (b) issued and signed a certificate of test and examination, specifying the safe working load of the hoist or lift.

(2) The certificate of test and examination referred to in paragraph (1)(b) shall be kept available for inspection.

(3) Subject to paragraph (10)(c), every hoist or lift used in a workplace shall be thoroughly examined by an authorised examiner at least once every 6 months or at such other intervals as the Commissioner may determine.

Lifting gears

20.

(1) No lifting gear of whatever material shall be used in a workplace unless an authorised examiner has —

- (a) tested and examined the lifting gear; and
- (b) issued and signed a certificate of test and examination, specifying the safe working load of the lifting gear.

(2) The certificate of test and examination referred to in paragraph (1)(b) shall be kept available for inspection.

(3) Every lifting gear used in a workplace shall be thoroughly examined by an authorised examiner at least once every year or at such other intervals as the Commissioner may determine. Electric generator, motor, transmission machinery, etc.

Lifting appliances and lifting machines

21.

- (1) No lifting appliance or lifting machine shall be used unless an authorised examiner has —
- (a) tested and examined the lifting appliance or lifting machine; and
 - (b) issued and signed a certificate of test and examination, specifying the safe working load of the lifting appliance or lifting machine.
- (2) The certificate of test and examination referred to in paragraph (1)(b) shall be kept available for inspection.
- (3) Every lifting appliance and lifting machine shall be thoroughly examined by an authorised examiner at least once every year or at such other intervals as the Commissioner may determine.

Conditions before steam boiler, steam receiver, air receiver or refrigerating plant pressure receiver may be used

27.

- (1) Subject to paragraph (2), it shall be the duty of the owner of any steam boiler, steam receiver, air receiver or refrigerating plant pressure receiver (referred to in this regulation as relevant equipment) who intends to put the relevant equipment into use in a workplace to —
- (a) obtain, in such form and manner as may be determined by the Commissioner, the approval of the Commissioner to use the relevant equipment;
 - (b) ensure that such examination and test by an authorised examiner as may be specified by the Commissioner has been satisfactorily carried out;
 - (c) obtain from the authorised examiner a report of the examination and test referred to in sub-paragraph (b), specifying the safe working pressure of the relevant equipment and stating the nature of the tests to which the relevant equipment and its fittings have been submitted;
 - (d) keep the report referred to in sub-paragraph (c) available for inspection; and
 - (e) mark the relevant equipment so as to enable it to be identified as the relevant equipment to which the report refers.

Steam boilers

28.

- (6) Every —
- (a) steam boiler referred to in paragraph (5), including all its fittings and attachments, shall be thoroughly examined by an authorised examiner at least once every 2 years and also after any extensive repair; and

- (b) surface of the external shell of a steam boiler referred to in paragraph (5) shall be examined by an authorised examiner at least once every 6 years, and for the purpose of such examination, the insulation on the shell shall be removed completely.

Steam receivers

29.

(6) Subject to paragraph (7) and regulation 31A, every steam receiver shall be examined by an authorised examiner —

- (a) at least once every 2 years; and
- (b) after any extensive repairs.

Air receivers

31.

(5) Subject to paragraph (6) and regulation 31A, every air receiver shall be —

- (a) thoroughly cleaned; and
- (b) examined by an authorised examiner at least once every 2 years.

ANNEX K – CLOSING SUBMISSIONS

**INQUIRY UNDER SECTION 26 OF THE WORKPLACE SAFETY AND
HEALTH ACT (CAP. 354A)
INTO THE FATAL ACCIDENT
AT STARS ENGRG PTE LTD'S WORKPLACE
AT 32E TUAS AVENUE 11**

CLOSING SUBMISSIONS BY STATE COUNSEL

Attorney-General's Chambers
Ms Kristy Tan, SC
Ms Ang Feng Qian
Mr Sivakumar Ramasamy
Ms Amanda Sum

Filed this 10th day of December 2021

TABLE OF CONTENTS

I.	INTRODUCTION	1
A.	APPOINTMENT OF INQUIRY COMMITTEE.....	1
B.	TERMS OF REFERENCE.....	2
C.	MOM INVESTIGATION TEAM	3
D.	INTERESTED PARTY	3
E.	HEARINGS	4
	1. First tranche: 20 September – 7 October 2021	4
	(a) Factual witnesses	5
	(b) Expert witnesses	9
	(c) Investigation officers	10
	2. Second tranche: 15 – 16 November 2021	11
F.	OUTLINE OF CLOSING SUBMISSIONS.....	14
II.	BACKGROUND FACTS.....	14
A.	BACKGROUND INFORMATION ON STARS.....	14
B.	THE TUAS SITE.....	16
C.	THE MIXER MACHINE	20
	1. Purchase and delivery of the Mixer Machine	20
	2. The Mixer Machine’s parts and associated equipment.....	20
	3. Installation of the Mixer Machine	26
D.	THE FIRE WRAP PRODUCTION PROCESS	27
	1. Conveying of raw materials.....	28

2.	Operating the Mixer Machine to make fire clay	29
3.	Assembling the fire wrap	31
E.	MANPOWER DEPLOYMENT AT THE TUAS SITE	32
F.	WORKING CONDITIONS AT THE TUAS SITE WORKSHOP	35
1.	Training to use the Mixer Machine	36
2.	Ventilation and dust conditions at the workshop.....	38
3.	Safety briefings	39
4.	Attire at the workshop	40
5.	Workload and working hours	41
III.	CHRONOLOGY OF KEY EVENTS	41
A.	12 JUNE 2020 – STARS INSTALLED AND COMMISSIONED THE MIXER MACHINE	41
B.	16 JUNE 2020 – STARS/CHUA XD PURCHASED 2 BUCKETS OF OIL FOR THE OIL JACKET.....	45
C.	7 AUGUST 2020 – IMAM OBSERVED THAT OIL WAS RUNNING OUT IN THE OIL JACKET AND REPORTED IT TO CHUA XD	45
D.	8 AUGUST 2020 – IMAM REPLACED A BURNED HEATER ON CHUA XD’S INSTRUCTIONS.....	47
E.	8 AUGUST 2020 – STARS/CHUA XD PURCHASED 4 BUCKETS OF OIL FOR THE OIL JACKET.....	50
F.	FROM 8 AUGUST 2020 ONWARDS – IMAM CLOSED THE FRONT PIPE AND BACK PIPE OF THE OIL JACKET ON CHUA XD’S INSTRUCTIONS	51
G.	28 AUGUST 2020 – STARS’ WORKERS OBSERVED SMOKE FROM THE OIL JACKET, BLACK OIL WITH SEDIMENTS AND DETERIORATED HEATER GASKETS, AND THESE WERE REPORTED TO MOE AND CHUA XD.....	52
H.	21 SEPTEMBER 2020 – IMAM OBSERVED SMOKE FROM THE OIL JACKET AND REPORTED IT TO MOE.....	54

I.	28 SEPTEMBER 2020: IMAM DISCOVERED A LEAK IN THE OIL JACKET AND THE LEAK WAS REPORTED TO MOE AND CHUA XD	55
J.	1 OCTOBER 2020 – STARS’ WORKERS OBSERVED DRAINED BLACK OIL WITH BLACK SEDIMENTS INSIDE	59
K.	12 OCTOBER 2020 – STARS’ WORKERS OBSERVED OIL LEAKING FROM THE OIL JACKET AGAIN AND THE LEAK WAS REPORTED TO MOE AND CHUA XD.....	61
L.	8 JANUARY 2021 – MOE OBSERVED SMOKE FROM THE OIL JACKET’S BOTTOM CORNERS AND REPORTED IT TO CHUA XD	64
M.	5 FEBRUARY 2021 – STARS/CHUA XD PURCHASED 4 BUCKETS OF OIL FOR THE OIL JACKET.....	67
N.	6 FEBRUARY 2021 – STARS’ WORKERS INSTALLED INSULATION OVER THE OIL JACKET ON CHUA XD’S INSTRUCTIONS.....	67
O.	12 FEBRUARY 2021 – FIRE ON THE MIXER MACHINE.....	69
P.	12 FEBRUARY 2021 – MARIMUTHU EXPRESSED CONCERN FOR HIS SAFETY	81
Q.	13 FEBRUARY 2021 – STARS’ WORKERS FOUND CRACKS ON THE OIL JACKET AND REPORTED IT TO CHUA XD	82
R.	15-16 FEBRUARY 2021 – NASIM PERFORMED WELDING REPAIRS ON THE MIXER MACHINE	85
S.	17 FEBRUARY 2021 – STARS’ WORKERS INSTALLED NEW INSULATION ON THE MIXER MACHINE	88
T.	24 FEBRUARY 2021 – SMALL FIRE ON THE MIXER MACHINE IN THE EARLIER PART OF THE MORNING.....	90
U.	24 FEBRUARY 2021 – ACCIDENT AT THE TUAS SITE WORKSHOP.....	104
V.	AFTERMATH OF THE ACCIDENT	109
	1. Property damage from the Accident.....	109
	2. Casualties from the Accident.....	110

(a)	Deceased persons	110
(b)	Injured persons	111
IV.	TOR A – CAUSES AND CIRCUMSTANCES OF THE ACCIDENT	115
A.	THE PROXIMATE TECHNICAL CAUSES OF THE ACCIDENT	115
1.	The explosion was chemical in nature caused by the ignition of thermic oil aerosols on a heated surface	117
2.	The rupture of the oil jacket was caused by high pressures created from the overheating of thermic oil.....	121
(a)	A physical rupture of the oil jacket is consistent with what was observed during operation of the Mixer Machine	123
(i)	<i>Deteriorated gaskets</i>	124
(ii)	<i>Oil drained from the oil jacket was black</i>	125
(iii)	<i>White smoke from the oil jacket</i>	125
(iv)	<i>Boiling sounds from the oil jacket</i>	126
(v)	<i>Cracks on the oil jacket</i>	127
(vi)	<i>Discolouration of the Mixer Machine</i>	128
(b)	A physical rupture of the oil jacket is consistent with the investigations conducted by Matcor and its implications	130
(i)	<i>Oil levels</i>	130
(ii)	<i>Dimples on welds</i>	132
(iii)	<i>Grain growth on the used heating elements</i>	134
(c)	A physical rupture of the oil jacket is consistent with the calculations on the temperature and pressure inside the oil jacket, and with observations on the strength of the welds	137
(d)	A physical rupture of the oil jacket is consistent with there being insufficient oxygen for a chemical explosion within the oil jacket	143
(e)	Hawkins’ theory that a chemical explosion within the oil jacket caused its rupture rests on speculation that the heating elements were exposed within the oil jacket on 24 February 2021 and further, on the flawed assumption that that was the only occasion they were so exposed.....	146

(f)	A physical rupture of the oil jacket was capable of taking place regardless whether the Mixer Machine was actually in operation at the point of the Accident	150
(g)	Summary of discussion on the physical rupture of the Mixer Machine	153
3.	The subsequent flash fires were most likely caused by the ignition of the potato starch suspended by the initial deflagration	154
(a)	Experts' positions on the cause of the three flashes	155
(b)	The lack of proper practices for combustible dusts at the Tuas Site created pockets of potato starch to be ignited	157
(c)	The presence of potato starch in the samples analysed after the incident	158
(d)	The ignition of smoke plumes from the incomplete combustion of the thermic oil is speculative and not in line with Maj Huang's experience	160
B.	THE ROOT CAUSES	163
1.	Stars failed to establish the safe working parameters for operating the Mixer Machine	164
(a)	Stars operated the Mixer Machine with insufficient oil in the oil jacket	166
(b)	Stars operated the Mixer Machine without monitoring the temperature of the oil in the oil jacket.....	172
(c)	Stars modified the Mixer Machine to operate as a closed system, and it did so without taking appropriate safety measures to guard against pressure build-up	178
2.	Stars failed to identify and respond appropriately to red flags and near-misses indicating over-heating, pressure build-up, and the oil jacket giving way	186
(a)	Burned heater on 8 August 2020.....	187
(b)	Deteriorated gaskets	188
(c)	Oil drained from the oil jacket was black.....	189
(d)	White smoke from the oil jacket	190
(e)	Boiling sounds from the oil jacket	194

(f) Fire on 12 February 2021	195
(g) Cracks on the oil jacket	199
(h) Small fire in the earlier part of the morning of 24 February 2021	201
3. Stars failed to consult the manufacturer or a competent person before performing in-house repairs on the Mixer Machine	208
4. Stars failed to ensure that those working at the Tuas Site had adequate instruction, information, training and supervision	210
5. Stars failed to take precautions for the use of potato starch powder at the Tuas Site workshop	215
V. TOR E: POTENTIAL OFFENCES DISCLOSED	220
A. STARS IS POTENTIALLY LIABLE UNDER SECTION 11 AND/OR 12 OF THE WSHA.....	222
B. STARS IS POTENTIALLY LIABLE UNDER SECTION 17(4) OF THE WSHA ..	227
C. CHUA XD IS POTENTIALLY LIABLE UNDER SECTION 48(1) OF THE WSHA	228
D. MOE IS POTENTIALLY LIABLE UNDER SECTION 15(3A) OF THE WSHA ..	230
E. MOE AND CHUA XD ARE POTENTIALLY LIABLE UNDER SECTION 204A OF THE PENAL CODE	232
VI. TOR B: RECOMMENDATIONS TO PREVENT THE RECURRENCE OF SUCH AN ACCIDENT AT WORKPLACES	238
A. REGULATION AND GUIDANCE	240
1. Improvements to regulatory regime.....	240
(a) Industrial machinery safety	240
(i) <i>Legislative review</i>	240
(ii) <i>Approved Codes of Practice (“ACOP”) and other guidance documents</i>	243
(iii) <i>Certification of machinery</i>	247
(b) Mitigation of dust hazards	249

(i) Legislative review	249
(ii) Gazetting SS 667 as an ACOP	250
2. Guidance for small and medium enterprises (“SMEs”)	251
(a) Publication or review of guidance documents	251
(b) Advisory panel	252
(c) bizSAFE as guidance for safety processes	254
B. EDUCATION AND OUTREACH	255
1. Current efforts.....	256
(a) General safety outreach	256
(b) Inspections for combustible dust hazards.....	257
2. Proposed improvements.....	258
(a) General safety training and dissemination of information	258
(b) Increasing awareness of combustible dust hazards	259
C. CULTURAL CHANGE AND OWNERSHIP	260
1. Current observations	261
2. Possible improvements	263
D. SUMMARY OF RECOMMENDATIONS	266
VII. CONCLUSION	267

I. INTRODUCTION

1 On 24 February 2021, an explosion and fire at Stars Engrg Pte Ltd’s (“**Stars**”) workplace at 32E Tuas Avenue 11, Singapore 636854 (“**Tuas Site**”), claimed the lives of three workers and injured seven others (the “**Accident**”). The explosion and fire originated from an industrial kneader/mixer machine (“**Mixer Machine**”) installed at the workplace and led to secondary combustible dust flash fires.

A. Appointment of Inquiry Committee

2 In view of the severity of the Accident, the Minister for Manpower appointed an Inquiry Committee (“**IC**”) under section 26(1) of the Workplace Safety and Health Act (Cap. 354A, 2009 Rev Ed) (“**WSHA**”) on 5 March 2021, to inquire into the causes and circumstances that led to the Accident (“**Inquiry**”).

3 The IC is chaired by the learned Senior District Judge Ong Hian Sun (“**SDJ**”), who is assisted by two assessors: Er Lucas Ng Hong Kiang, General Manager of Plant, Petrochemical Corporation of Singapore (Private) Limited; and Dr Peter Nagler, A*Star Chief Innovation Officer and Executive Director of the Institute of Chemical and Engineering Sciences (“**ICES**”).

B. Terms of Reference

4 The Terms of Reference (“**TOR**”) issued to the IC are as follows:¹

(a) Inquire into and ascertain the causes and circumstances of the Accident (“**TOR A**”).

(b) Make recommendations to prevent the recurrence of such an accident at workplaces (“**TOR B**”).

(c) Consider the evidence put before the IC as led by State Counsel.

(d) Make and submit a report of the IC’s proceedings, findings, recommendations and any other relevant observations related to the cause of the Accident to the Minister for Manpower.

(e) If the SDJ is of the opinion that criminal proceedings ought to be instituted against any person in connection with the Accident, he shall also forward a copy of the report to the Public Prosecutor (“**TOR E**”).

¹ Ministry of Manpower, Press Release, Annex B: “Terms of Reference for Inquiry Committee into the Fatal Accident at Stars Engrg on 24 February 2021, Appointed under Section 26 of the Workplace Safety and Health Act”, 5 March 2021.

C. MOM Investigation Team

5 The investigation into the Accident was led by an investigation team from the Ministry of Manpower (“**MOM**”), Occupational Safety and Health Division (“**MOM Investigation Team**”), comprising:²

(a) Chief Investigation Officer – Ms Lim Yin Yin Jaime (“**Ms Lim**”),³ who was then the Deputy Director (currently Director) of the Major Hazards Department;

(b) Assistant Chief Investigation Officer – Mr Mohamed Haniffa Ibrahim, Assistant Director of the Occupational Safety and Health Inspectorate; and

(c) Investigation Officer – Mr Lucas SH Ng, Senior Investigation Officer of the Occupational Safety and Health Inspectorate.

D. Interested party

6 Stars was represented at the IC hearing as an interested party by counsel from Rajah & Tann Singapore LLP. Stars is a fire protection contractor and is in the business of providing design-built fire protection systems.⁴

² S-289 (MOM’s Investigation Report), [1.3.1].

³ SW-21.

⁴ Statement of Agreed Facts (“**SOAF**”), [3].

7 The Accident took place at Stars’ workshop located on the ground floor of the Tuas Site (the “**workshop**”). At this workshop, Stars’ workers produced a fire-rated insulation wrap (“**fire wrap**”). A key component of the fire wrap was a clay material (“**fire clay**”) which the workers made using the Mixer Machine. The fire clay would be wrapped with other materials to assemble the finished fire wrap product. We will elaborate on this background, which is material to appreciating the circumstances and causes of the Accident, at Section II of these submissions below.

E. Hearings

8 The IC hearings took place over two tranches in State Court no. 8A:

(a) 20 September – 7 October 2021; and

(b) 15 – 16 November 2021,

with 15 December 2021 fixed for oral closing submissions by the parties.

9 The first tranche of the IC hearing focused on TOR A, while the second tranche of the IC hearing addressed TOR B.

1. First tranche: 20 September – 7 October 2021

10 The first tranche of the hearing lasted 14 days. In total, the IC heard testimony from 22 witnesses in relation to the causes and circumstances of the

Accident. State Counsel called 21 witnesses, of which 15 were witnesses of fact, four were experts, and two were investigation officers. Stars called one expert witness.

11 In addition, documentary evidence was adduced by the parties. The documentary evidence tendered by State Counsel was marked “S”, and totalled 311 exhibits, comprising 336 separate documents.⁵ Stars tendered one expert report, which was marked “ST-1”.

(a) *Factual witnesses*

12 The testimony of the factual witnesses was adduced by way of signed statements (“**witness statements**”), supplemented by oral evidence. These witness statements were marked “SS”, as were documents prepared by State Counsel. In total, there were 17 “SS” exhibits.

13 State Counsel led evidence from these 15 factual witnesses:⁶

⁵ Some related documents (eg, attachments to emails) were given a single “S” marking and given a sub-marking “A”, “B”, “C”.

⁶ Listed in order of their assigned witness numbers.

(i) In relation to Stars

(a) Mr Imam (“**Imam**”)⁷ – worker involved in production at the workshop from around June to early October 2020, and end-December 2020 to early January 2021.

(b) Mr Mehedi (“**Mehedi**”)⁸ – worker involved in production at the workshop from June 2020 to 24 February 2021.

(c) Mr Molla Md Nasim (“**Nasim**”)⁹ – worker involved in production at the workshop in 2020; welder.

(d) Mr Pandi Murugantham (“**Murugan**”)¹⁰ – Project Manager for projects at external worksites.

(e) Mr Chua Xing Da (“**Chua XD**”)¹¹ – sole director and sole shareholder of Stars; overall-in-charge of production at the Tuas Site.

(f) Mr Hossain Jitu (“**Jitu**”)¹² – working at the workshop on 24 February 2021.

⁷ SW-1; Statement marked SS-2.

⁸ SW-2; Statement (redacted) marked SS-3.

⁹ SW-3; Statement marked SS-4.

¹⁰ SW-4; Statement marked SS-5.

¹¹ SW-5; Statement marked SS-6.

¹² SW-6; Statement (redacted) marked SS-9.

- (g) Mr Molla Md Yousuf (“**Yousuf**”)¹³ – working at the workshop on 24 February 2021.
- (h) Mr Rahad Asfaquzzaman (“**Rahad**”)¹⁴ – working at the workshop on 24 February 2021.
- (i) Mr Ahmmed Lizon (“**Lizon**”)¹⁵ – working at the workshop on 24 February 2021.
- (j) Mr Lwin Moe Tun (“**Moe**”)¹⁶ – Project Engineer overseeing production at the Tuas Site.
- (k) Mr Sarkar Shibu (“**Shibu**”)¹⁷ – Safety Coordinator.
- (l) Mr Chua Shi Yong Desmond¹⁸ – company secretary and general manager.

¹³ SW-7; Statement marked SS-10.

¹⁴ SW-8; Statement marked SS-11.

¹⁵ SW-9; Statement marked SS-12.

¹⁶ SW-12; Statement marked SS-7.

¹⁷ SW-13; Statement marked SS-15.

¹⁸ SW-14; Statement marked SS-16.

(ii) From P3 Project Pte Ltd

(m) Mr Miah Md Azam (“**Miah**”)¹⁹ – worker at P3 Project Pte Ltd (“**P3**”), which occupies units opposite Stars’ workshop; injured by the Accident.

(n) Mr Zhao Jian Wang (“**Zhao**”)²⁰ – supervisor at P3; injured by the Accident.

(iii) From Ming Hup Trading Pte Ltd

(o) Ms Sharon Lee Sio Cheng (“**Sharon**”)²¹ – Sales Manager at Ming Hup Trading Pte Ltd (“**MHT**”), supplier of Idemitsu Daphne Thermic 32-S oil (“**thermic oil**” or “**oil**”) to Stars.

¹⁹ SW-10; Statement marked SS-13.

²⁰ SW-11; Statement marked SS-14.

²¹ SW-15; Statement marked SS-17. Sharon did not give oral evidence at the IC hearing as her attendance was dispensed with by consent.

(b) *Expert witnesses*

14 The following experts submitted reports in relation to the causes of the Accident:

(a) Matcor Technology & Services Pte Ltd (“**Matcor**”) submitted a report dated 10 September 2021 (the “**Matcor Report**”).²² Matcor also tendered an addendum report dated 10 November 2021.²³

(b) Dr Shaik Mohamed Salim (“**Dr Salim**”),²⁴ Principal Specialist A*STAR, ICES, tendered a report dated 13 September 2021 (“**Dr Salim’s Report**”),²⁵ and an addendum report dated 4 October 2021 (“**Dr Salim’s Addendum**”).²⁶

(c) Emeritus Prof Chew Yong Tian (“**Prof Chew**”) ²⁷ submitted a report dated 13 September 2021 (“**Prof Chew’s Report**”).²⁸

22 S-279.

23 S-299.

24 SW-18.

25 S-283.

26 S-283A.

27 SW-19.

28 S-290.

(d) Stars' instructed expert, Dr David Rose ("**Dr Rose**")²⁹ from Hawkins & Associates (Singapore) Pte Ltd ("**Hawkins**"), submitted a report dated 15 September 2021 (the "**Hawkins Report**").³⁰

15 The IC heard oral evidence from two of Matcor's representatives, namely Mr Robert Shandro ("**Mr Shandro**")³¹ and Mr Ashley Ng ("**Mr Ng**")³²; Dr Salim; Prof Chew; and Dr Rose, as to the findings in their respective reports during the first tranche of the hearing.

(c) *Investigation officers*

16 In addition, two investigation reports were submitted to the IC:

(a) Ms Lim submitted a report dated 4 October 2021 detailing the MOM Investigation Team's findings on the Accident ("**MOM's Investigation Report**"), and gave oral evidence on the same at the hearing.³³

(b) The Singapore Civil Defence Force ("**SCDF**"), Fire Investigation Unit, tendered a report dated 14 September 2021 ("**SCDF's Investigation**

²⁹ STW-1.

³⁰ ST-1.

³¹ SW-16.

³² SW-17.

³³ S-289.

Report").³⁴ SCDF's Investigation Report was supplemented by oral evidence at the hearing from Major Huang Weikang ("**Maj Huang**").³⁵

17 After the first tranche, the IC also received written answers from the Chinese manufacturer of the Mixer Machine, Laizhou Keda Chemical Machinery Co., Ltd ("**Laizhou Keda**"), to written queries that had been posed by the MOM Investigation Team, Stars and the IC, all via email.³⁶

2. *Second tranche: 15 – 16 November 2021*

18 The second tranche of the hearing took place over the course of two days. In total, the IC received 17 sets of written representations on recommendations to prevent the recurrence of future similar accidents at workplaces, submitted by:

- (a) Dr Salim;³⁷
- (b) Singapore Manufacturing Federation ("**SMF**");³⁸
- (c) Institution of Engineers ("**IES**");³⁹

³⁴ S-288.

³⁵ SW-20.

³⁶ S-292 - S-298B, S-311A.

³⁷ S-300.

³⁸ S-301.

³⁹ S-302.

- (d) Singapore Institution of Safety Officers (“**SISO**”);⁴⁰
- (e) SCDF;⁴¹
- (f) Workplace Safety and Health Council (“**WSHC**”);⁴²
- (g) MOM;⁴³
- (h) Singapore Food Agency;⁴⁴
- (i) Singapore Welding Society;⁴⁵
- (j) Singapore National Employers Federation;⁴⁶ and
- (k) Members of the public.⁴⁷

⁴⁰ S-303.

⁴¹ S-304.

⁴² S-305.

⁴³ S-306.

⁴⁴ S-307.

⁴⁵ S-308.

⁴⁶ S-309.

⁴⁷ The written representations from the members of the public (namely TUV Rheinland Singapore, AllAlloy Dynaweld Pte Ltd, Mr Tang Teen Tuck, Mr Timothy Koh, Mr Au Lik Hang Terence, and Mr Lai Hong Yew Jeffrey) were collectively marked S-310.

19 The IC also heard oral evidence from the following seven representatives on their written representations:

- (a) Dr Salim;
- (b) Mr Ong Beng Yang, representative of SMF;⁴⁸
- (c) Mr Felipe Ong, representative of IES;⁴⁹
- (d) Mr Niranjan Masurekar, representative of SISO;⁵⁰
- (e) Col Ng Geok Meng, representative of SCDF;⁵¹
- (f) Mr Christopher Koh, representative of WSHC;⁵² and
- (g) Mr Silas Sng, representative of MOM.⁵³

48 SW-22.

49 SW-23.

50 SW-24.

51 SW-25.

52 SW-26.

53 SW-27.

F. Outline of Closing Submissions

20 In these submissions, we will address the issues arising from the TOR as follows:

- (a) Section I: Introduction.
- (b) Section II: Background Facts.
- (c) Section III: Chronology of Key Events.
- (d) Section IV: TOR A – Causes and Circumstances of the Accident.
- (e) Section V: TOR E – Potential Offences Disclosed.
- (f) Section VI: TOR B – Recommendations to Prevent the Recurrence of such an Accident at Workplaces.
- (g) Section VII: Conclusion.

II. BACKGROUND FACTS

A. Background information on Stars

21 Stars is a private company (UEN: 201024323G) incorporated in November 2010, with its registered address at 15 Changi North Street 1, #01-24 i-Lofts @

Changi, Singapore 498765 (“**Changi Site**”). Stars’ sole director and only shareholder is Chua XD.⁵⁴

22 There are three main business areas which Stars is involved in. Stars’ core business is the installation of fire protection systems. These include mechanical systems (*eg*, sprinklers, risers, hydrants) and electrical systems (*eg*, fire alarm systems, emergency communication systems).⁵⁵ Stars’ clients are main contractors at external construction project sites.⁵⁶

23 Stars also did works for mechanical and electrical systems, and has experience in the operation, installation and maintenance of heavy motors and hydraulic machineries.⁵⁷

24 In connection with its core business of providing fire protection systems, Stars sometimes uses a fire-rated insulation wrap (*ie*, the “fire wrap”) under the brand name “Shield+” to wrap piping and ducting systems in building construction for its clients. This fire wrap is manufactured by Stars at the Tuas Site workshop. A separate company, Shield + Pte Ltd (“**Shield+**”), owns the wrap including the intellectual property in the wrap.⁵⁸ Chua XD is Shield+’s sole director. He co-owns

⁵⁴ SOAF, [2].

⁵⁵ SOAF, [3].

⁵⁶ SS-6 (Chua XD), [12].

⁵⁷ SS-6 (Chua XD), [12].

⁵⁸ SOAF, [4].

Shield+ with two other shareholders, Mr Alvin Loo and Mr Goh Yong Ping, who are not involved in the day-to-day operations of Shield+.⁵⁹

25 The commercial arrangement between Stars and Shield+ was that Shield+ engaged Stars to produce the fire wrap. Stars accordingly deployed its workers to produce the fire wrap at the Tuas Site and charged Shield+ for the provision of manpower, and the rental costs in respect of the Tuas Site for the production and storage of the fire wrap. As part of this arrangement, when Stars had any projects involving the use of the fire wrap, Shield+ would charge Stars a discounted price for the wrap. Stars also let Shield+ register the Tuas Site as Shield+'s corporate address.⁶⁰

B. The Tuas Site

26 Stars operates out of two locations – the Changi Site and the Tuas Site.⁶¹

27 The Tuas Site is in an industrial estate called Platinum@Pioneer at 32 Tuas Avenue 11, Singapore 639109. The development comprises two buildings housing terrace units. Stars rented the Tuas Site in June 2019.⁶²

⁵⁹ SOAF, [5].

⁶⁰ SOAF, [6]; SS-6 (Chua XD), [29].

⁶¹ SS-6 (Chua XD), [15].

⁶² SOAF, [7].

28 To the left of the Tuas Site (when facing its front from outside the workshop), and sharing an adjoining wall, is Unit 32F which is leased by Alif-Engineering Pte Ltd (“**Alif-E**”). Opposite the Tuas Site workshop are two units (Units 32A and B) leased by P3.⁶³

29 The Tuas Site has three floors. The ground floor is the workshop where the fire wrap is produced. The second floor is used to store materials. The third floor is a factory-converted dormitory at which some of Stars’ workers live.⁶⁴

30 Upon receiving the keys to the Tuas Site in June 2019, Stars began renovations to convert the space at the third floor into a dormitory. The renovation of the third floor took about eight months, from June 2019 to February 2020.⁶⁵

31 Thereafter, the ground and second floors of the Tuas Site were renovated by Stars’ workers between March and August 2020. The works continued over the ‘Circuit Breaker’ period, which began on 7 April 2020.⁶⁶

32 As part of the renovations, three of Stars’ workers – Lizon, Mehedi and Nasim, constructed a raised platform at the back of the workshop (the “**Platform**”).

⁶³ SOAF, [9].

⁶⁴ SOAF, [8].

⁶⁵ SS-6 (Chua XD), [37].

⁶⁶ SS-6 (Chua XD), [37].

The Platform was constructed sometime in April 2020,⁶⁷ based on a layout plan approved by a Professional Engineer from DP Engineers.⁶⁸ The Stars workers built the Platform by welding I-beams together and securing them with bolts and nuts, before installing an additional metal plate over the I-beams to reinforce the structure.⁶⁹

33 Two roller machines were also placed in the workshop, which were used to flatten the fire clay for the assembly of the fire wrap (see fire wrap production process at [50] below).

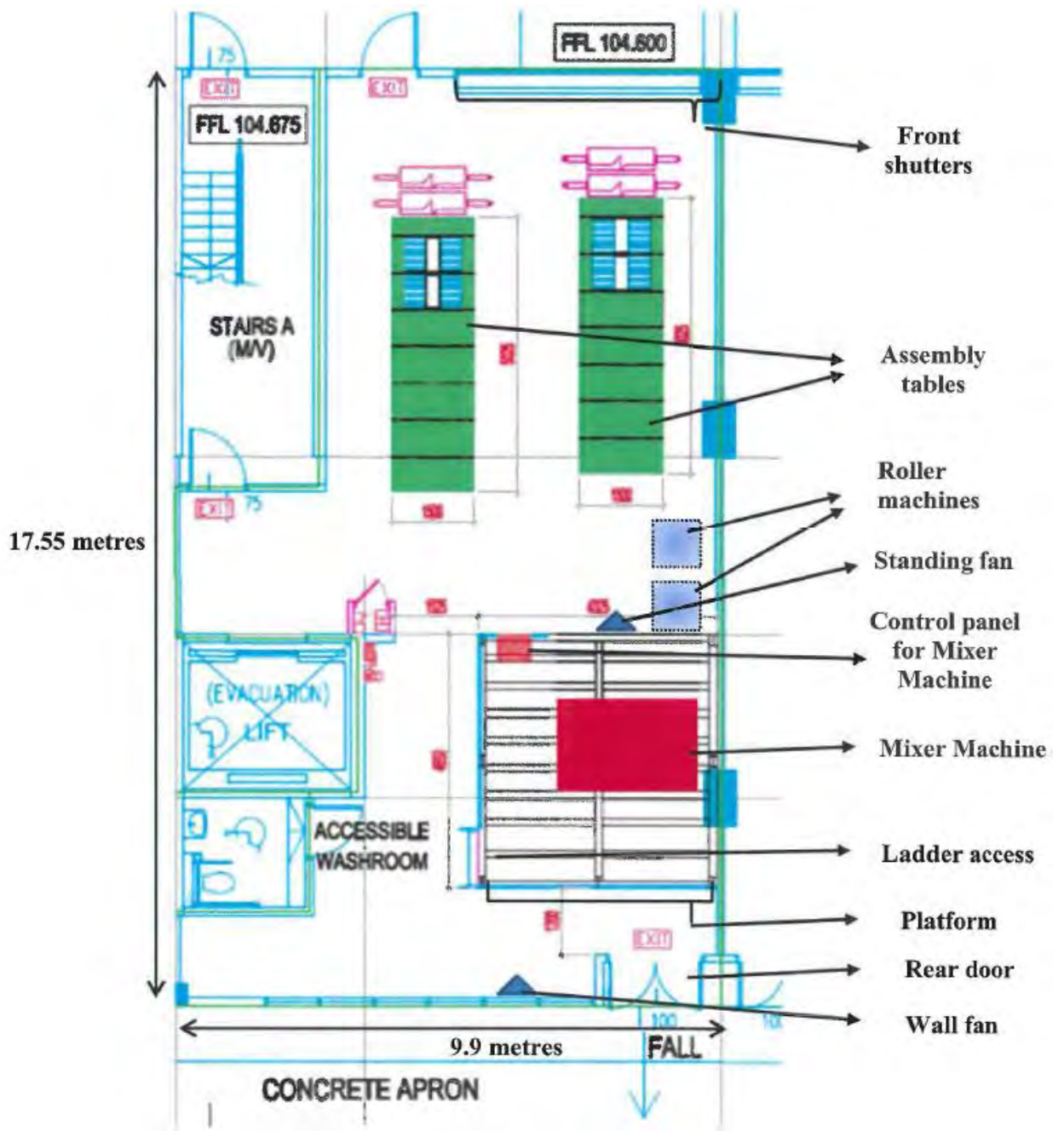
34 Below is a 2D sketch of the Tuas Site workshop, showing, *inter alia*, the respective locations of the Platform, the Mixer Machine, the roller machines and the assembly tables during production in February 2021, when the Accident occurred:

⁶⁷ SS-6 (Chua XD), [42].

⁶⁸ SS-6 (Chua XD), [42].

⁶⁹ SS-4 (Nasim), [22] and [23].

2D sketch of the Tuas Site workshop⁷⁰



⁷⁰ SOAF, [16].

C. The Mixer Machine

1. Purchase and delivery of the Mixer Machine

35 Chua XD purchased the Mixer Machine sometime in August 2019, from Laizhou Keda in China, via the ‘Alibaba’ online platform,⁷¹ for USD11,700.⁷²

36 The Mixer Machine was delivered to Stars in October or November 2019.⁷³ It came ready assembled, with a one-year warranty from October 2019 to September 2020.⁷⁴

2. The Mixer Machine’s parts and associated equipment

37 The main body of the Mixer Machine comprised the following components relevant to this Inquiry:⁷⁵

- (a) A motorised cover/lid at the top.
- (b) Under the cover, a mixing chamber with sigma-shaped blades, which rotated to mix the water and other raw materials used to make

⁷¹ SOAF, [15].

⁷² SS-6 (Chua XD), [46]; S-240.

⁷³ SS-6 (Chua XD), [51].

⁷⁴ SS-6 (Chua XD), [52].

⁷⁵ SS-7 (Moe), [21].

fire clay. When mixing was completed, the mixing chamber could be tilted forward for removal of the contents.⁷⁶

- (c) An outer “**oil jacket**” encasing the front, back and bottom of the mixing chamber. The oil jacket could be filled with thermic oil to act as a medium for heat transfer to the contents in the mixing chamber.

- (d) Nine heaters inserted into the bottom of the oil jacket. When turned on, the heaters heated the thermic oil in the oil jacket. Each heater comprised three U-shaped metal tubes/coils, the ends of which connected to six terminals on the heater flange.⁷⁷ The metal tubes of the heaters would be inserted into the bottom of the oil jacket through openings for the heaters. There were gaskets placed between the openings and the heater flanges. From the outside, the flanges would be bolted to the openings, to keep the heaters in place. Yellow hub caps covered the heater terminals. These yellow caps protruded from the back of the machine.⁷⁸

⁷⁶ SS-7 (Moe), [22].

⁷⁷ See S-127.

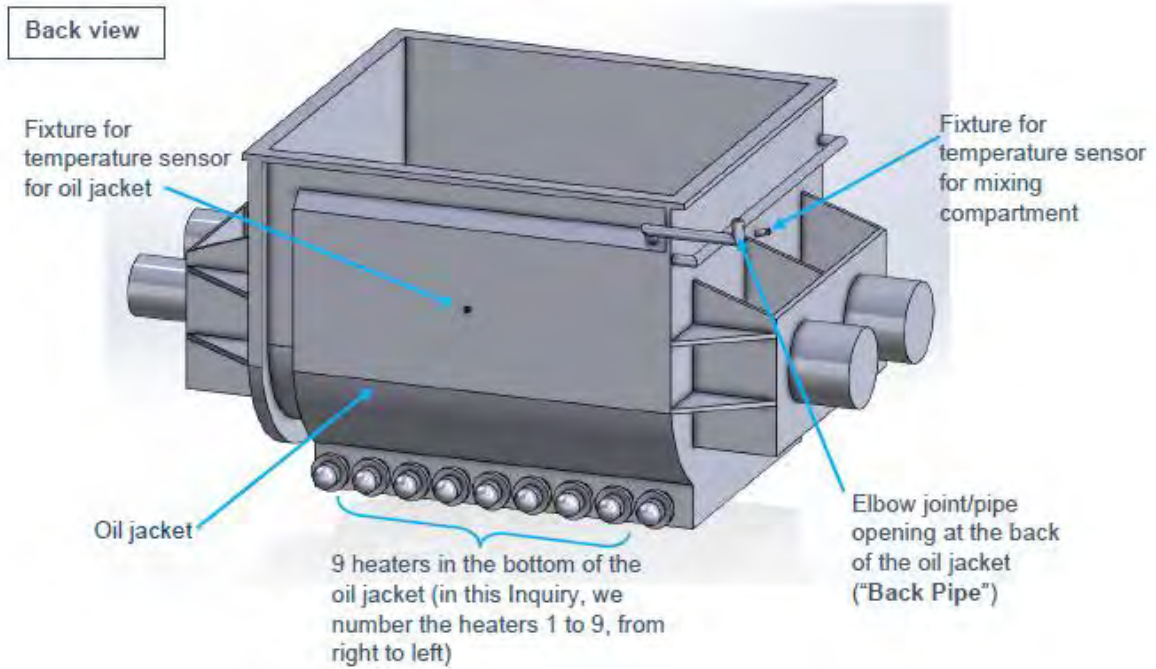
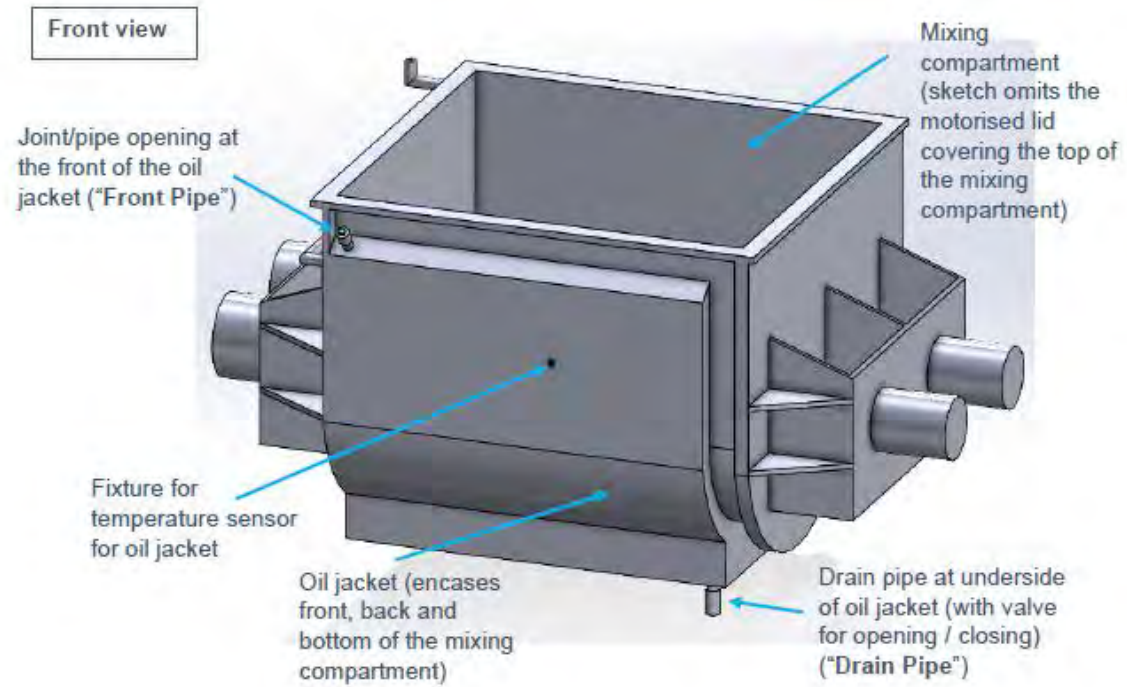
⁷⁸ See S-59.

- (e) An elbow joint/pipe opening at the back of the machine (“**Back Pipe**”). Thermic oil was added to the oil jacket through a blue funnel which was attached to the Back Pipe at the point of delivery.⁷⁹
- (f) A joint/pipe opening at the front of the machine (“**Front Pipe**”). Stars used this opening to check on the thermic oil level using a dipstick but this opening would otherwise be closed with the end cap that came with the Mixer Machine (see [39(c)] below).
- (g) A drain pipe at the underside of the front bottom right corner of the machine (“**Drain Pipe**”), from which the thermic oil in the oil jacket could be drained out. The Drain Pipe had a valve which was turned to open or close the Drain Pipe opening.
- (h) Three fixtures on the Mixer Machine for fixing the temperature sensors that came with the Mixer Machine (see [39(d)] below).

38 Below is a 3D sketch of the front and back of the Mixer Machine with the relevant components labelled:

⁷⁹ SS-6 (Chua XD), [122(a)].

3D sketch of the front and back of the Mixer Machine



39 The Mixer Machine also came with the following additional items:

(a) A control panel to operate the Mixer Machine. The control panel was connected to the Mixer Machine, and was placed on the Platform next to the back of the Mixer Machine;

(b) Nine extra heaters;

(c) One end cap. When the Mixer Machine is tilted (see [37(b)] above), the Front Pipe would have to be closed to prevent oil in the oil jacket from flowing out. The Mixer Machine was delivered with the end cap placed on the Front Pipe; and

(d) Two resistance temperature detectors/sensors (“**RTD**” or “**temperature sensor**”):

(i) One temperature sensor was for measuring the oil jacket temperature and was labelled as such.⁸⁰ There were fixtures on the front and back of the oil jacket, to which one end of this temperature sensor could be attached. Readings from this temperature sensor would show up on the jacket temperature screen on the control panel. This temperature sensor operated on an interlock system – a

⁸⁰ Notes of Evidence (“**NE**”) 27 September 2021, pp. 6:23-7:7 (Chua XD EIC).

specific temperature could be pre-set, and once reached, the heaters would be automatically switched off.⁸¹

(e) The other temperature sensor was for measuring the temperature of the material in the mixing chamber. There was a fixture on the side of the Mixer Machine (which was the exterior wall of the mixing chamber), to which one end of this temperature sensor could be attached. Readings from this temperature sensor would show up on the material temperature screen on the control panel.

It is undisputed, however, that when operating the Mixer Machine, Stars did not attach the temperature sensors to their respective fixtures on the Mixer Machine. Instead, Stars placed one of the temperature sensors (used interchangeably) into the mixing chamber to measure the temperature of the water being heated in there. The temperature of oil in the oil jacket was not measured or monitored (see [323]-[331] below).⁸²

⁸¹ S-279 (Matcor Report), [2.2].

⁸² SS-6 (Chua XD), [79]; NE 27 September 2021, p. 82:18-21 (Chua XD XX).

40 Chua XD also obtained a user guide for the Mixer Machine from Laizhou Keda (“**User Guide**”).⁸³ The User Guide stated the following in relation to the oil jacket:⁸⁴

- (a) Design temperature: 200°C;
- (b) Operating temperature: 70-160°C; and
- (c) Working pressure: ≤0.2Mpa.

3. *Installation of the Mixer Machine*

41 The Mixer Machine was installed on the Platform on 12 June 2020 by Chua XD, Imam and some Stars workers. The Mixer Machine was lifted up from the ground by a lorry crane, and placed on the Platform. It was not bolted or welded to the Platform. An isolation pad was placed between the Mixer Machine and the Platform, to dampen the vibrations when the motor of the Mixer Machine was running.⁸⁵

42 After the Mixer Machine was placed on the Platform, the power cables, the nine heater cables, the oil pump cables and the hydraulic solenoid cables were connected according to the instructions from Laizhou Keda. Before the power was

⁸³ S-271.

⁸⁴ S-271, p. 4, Section Eight.

⁸⁵ SS-6 (Chua XD), [56].

connected to the Mixer Machine, a Megger test was carried out on all the cables using a megohmmeter to test if any of the cables were damaged and to ensure that there were no electricity leakages.⁸⁶

43 Testing and commissioning of the Mixer Machine was done later that same day on 12 June 2020. We elaborate on the details of the testing and commissioning process, as well as the subsequent events that took place on 12 June 2020, at Section III.A below when we discuss the chronology of key events leading up to the Accident.

D. The fire wrap production process

44 From June 2020, Stars began testing and doing trial runs for the production of fire clay using the Mixer Machine and the assembly of the fire wrap at the Tuas Site workshop.⁸⁷

45 In gist, the fire wrap production involved adding a number of raw materials into the Mixer Machine to make fire clay. These raw ingredients were namely water, potato starch powder, boric acid, silicon oil, aluminium trihydrate and bentonite clay.⁸⁸ After the fire clay was ready, it would then be flattened and assembled with other layers of material to make the fire wrap.

⁸⁶ SS-6 (Chua XD), [57].

⁸⁷ SOAF, [10].

⁸⁸ SOAF, [13].

46 The production of fire clay/fire wrap at the Tuas Site workshop took place over two broad periods of time:

(a) Trial runs for production took place from June to October 2020.⁸⁹ During this period, Stars made small pieces of fire wrap (measuring around 50-90cm wide x 1.2m long)⁹⁰ using smaller quantities of raw materials and fire clay.⁹¹

(b) Actual production of fire wrap began in October 2020 and continued until the Accident on 24 February 2021. During this period, Stars made bigger fire wraps (measuring around 1.1m wide x 5m long).⁹² At the height of production in January and February 2021, the Mixer Machine was used to mix around 800kg of fire clay per batch, twice a day.⁹³

1. Conveying of raw materials

47 The raw materials for making the fire clay were stored at the second floor of the Tuas Site. The workers would transport the raw materials down to the

⁸⁹ SS-2 (Imam), [21]-[22]; SS-3 (Mehedi), [18]-[19].

⁹⁰ SS-3 (Mehedi), [18].

⁹¹ SS-7 (Moe), [28].

⁹² SS-3 (Mehedi), [74].

⁹³ SS-7 (Moe), [27]-[28].

workshop on the ground floor using a trolley and the lift, whenever a new batch of fire clay was going to be made.⁹⁴

2. *Operating the Mixer Machine to make fire clay*

48 The quantities of raw materials used, and the mixing times, would change depending on the quantity of fire clay being produced. As mentioned at [46(b)] above, batches of around 800kg of fire clay were made in January and February 2021, at the height of production.

49 Based on the amounts of raw materials needed to make a batch of around 800kg of fire clay, these were the steps for making the fire clay with the Mixer Machine:⁹⁵

(a) First, the cover/lid at the top of the Mixer Machine was opened. About 176kg (*ie*, 176L) of water was poured into the mixing chamber of the Mixer Machine and a temperature sensor would be dropped into the same chamber. The cover/lid was then closed.

(b) Second, the Mixer Machine's heaters were turned on to heat the water up to 80 to 90°C. This was done by turning on all three heater switches

⁹⁴ SS-3 (Mehedi), [23].

⁹⁵ SS-7 (Moe), [27].

on the control panel.⁹⁶ The heating of the water to the required temperature usually took about 35 to 40 minutes. After that, the heaters were turned off manually and the temperature sensor would be removed from the mixing chamber of the Mixer Machine.

(c) Third, 88kg of potato starch powder (about 3½ 25kg sacks) was added into the mixing chamber of the Mixer Machine. The rotating blades were then turned on. During both the trial run and actual production phases, the required sacks of potato starch powder were manually carried up onto the Platform to be poured/emptied into the Mixer Machine.⁹⁷ The Mixer Machine mixed the water and potato starch powder for about 10-15 minutes.

(d) Fourth, 32kg of boric acid powder (about 1¼ 25kg bags) was added into the mixture. The bags of boric acid powder were also manually carried up onto the Platform. The Mixer Machine continued mixing for another 10-15 minutes.

(e) Fifth, 22kg of liquid silicon (slightly more than 1 20kg bucket) was added into the mixture. The Mixer Machine continued mixing for another 10-15minutes.

⁹⁶ NE 20 September 2021, pp. 119:15-120:5 (Imam EIC); NE 21 September 2021, p. 58:18-21 (Mehedi EIC).

⁹⁷ SS-3 (Mehedi), [77].

(f) Sixth, about 300kg of ATH and 100kg of bentonite clay were added into the mixture using a large container bag and hoist/pulley system that was implemented in the workshop around October 2020.⁹⁸ The Mixer Machine continued mixing for another 15 minutes.

(g) Thereafter, the fire clay mixture (about 800kg of it) was ready.

3. *Assembling the fire wrap*

50 After the fire clay was ready, the next steps were to:⁹⁹

(a) Tilt the Mixer Machine onto its side so that the fire clay could be scooped out, and transfer the fire clay to the ground floor of the workshop, near the rear of the workshop.

(b) Once on the ground floor, cut the fire clay into smaller pieces and flatten the smaller pieces using roller machines on the ground floor.

(c) Assemble the fire wrap at two assembly tables on the ground floor. This involved first placing a sheet of aluminium foil on the assembly table, followed by layers of various other materials:

⁹⁸ SS-3 (Mehedi), [75] and [76].

⁹⁹ SS-7 (Moe), [29].

(i) During the trial run phase from June to October 2020, the layers following the sheet of aluminium foil were: (1) ceramic fibre, (2) wire mesh; (3) fire clay; and (4) ceramic fibre. These layers were then wrapped up in the bottom-most sheet of aluminium foil and taped with aluminium tape.¹⁰⁰ These were the steps for making “Shield+” wrap for piping insulation. For fire wrap used for ducting insulation, there was an additional layer of ceramic fibre (*ie*, a further step (5) after step (4)).¹⁰¹

(ii) Sometime around October 2020, adjustments were made to the assembly process for actual production – shrink wrap was now used to wrap the layers of material, and sealed using a fire torch, before the aluminium foil was used for the outer-most wrapping. The wire mesh was also substituted with fibre glass mesh.¹⁰²

E. Manpower deployment at the Tuas Site

51 As stated above at [44], Stars began testing the production of fire clay using the Mixer Machine and the assembly of the fire wrap at the Tuas Site workshop from around June 2020.

¹⁰⁰ SS-3 (Mehedi), [35].

¹⁰¹ SS-7 (Moe), [29(c)].

¹⁰² SS-3 (Mehedi), [80].

52 Initially, there were four workers deployed to make fire wrap at the Tuas Site workshop – Imam, Mr Shohel Md (“**Shohel**”), Nasim and Mehedi. Imam was in charge at the Tuas Site workshop during this time, with Moe overseeing the team/fire wrap production at the Tuas Site workshop.

53 While Imam was at the workshop, he was in charge of operating the Mixer Machine, with Shohel and Mehedi assisting him. We discuss the details of the training given to these workers in respect of operating the Mixer Machine at [60]-[62] below.

54 Sometime in October 2020, Imam stopped working at the Tuas Site workshop due to disagreements with Chua XD, and Mr Anisuzzaman MD (“**Anis**”) was deployed to take over Imam’s duties.¹⁰³ Imam returned to work at the workshop for a brief period in end-December 2020, before he was again asked to leave on 8 January 2021, whereupon he was deployed to work at Stars’ project sites permanently.¹⁰⁴

55 When Imam left in January 2021, Anis was in charge for about ten days, before Mr Subbaiyan Marimuthu (“**Marimuthu**”) was deployed to work at the

¹⁰³ SS-6 (Chua XD), [89].

¹⁰⁴ SS-6 (Chua XD), [90].

workshop. Marimuthu was appointed by Chua XD as the supervisor of the Tuas Site that same month.¹⁰⁵

56 From January 2021 to 17 February 2021, the fire wrap production team at the Tuas Site comprised four workers – Marimuthu, Shohel, Anis and Mehedi. During this time, Marimuthu was mainly in charge of the Mixer Machine, with Shohel assisting him. Anis was in charge of the roller machines, and Mehedi’s main task was to assemble the fire wraps at the assembly tables together with Shohel.¹⁰⁶ All four workers would help each other out at the various stages of the fire wrap production process, such as carrying the raw materials down from the second floor store, weighing the raw materials, operating the Mixer Machine, flattening the fire clay, and assembling the fire wraps.

57 On 18 February 2021, four workers joined the fire wrap production team at the Tuas Site workshop – namely Jitu, Yousuf, Rahad, and Mr Rahman Mohammad Ashikur (“**Ashikur**”). Lizon subsequently replaced Ashikur and started working at the Tuas Site workshop on 22 February 2021. These extra workers were added to meet the increased demand for fire wrap during that time.¹⁰⁷

¹⁰⁵ SS-6 (Chua XD), [91].

¹⁰⁶ SS-3 (Mehedi), [85].

¹⁰⁷ SS-6 (Chua XD), [93].

58 From 22 February 2021, there were eight workers working at the Tuas Site workshop – Anis, Mehedi, Shohel, Marimuthu, Jitu, Yousuf, Rahad and Lizon.¹⁰⁸ During this time, the respective roles of the workers at the workshop became more fixed.¹⁰⁹

(a) Marimuthu was in charge of operating the Mixer Machine to make the fire clay, with Shohel assisting him.

(b) Anis and Lizon cut the fire clay and flattened the pieces using the two roller machines.

(c) Marimuthu and Shohel sometimes also assisted Anis and Lizon to cut the fire clay into smaller pieces for flattening.

(d) Jitu, Rahad, Yousuf and Mehedi assembled the fire wraps at the two assembly tables. Yousuf and Rahad worked together at one table, while Jitu and Mehedi worked together at the other table.

F. Working conditions at the Tuas Site workshop

59 We set out below the workers' accounts of their working conditions at the Tuas Site workshop.

¹⁰⁸ SOAF, [28].

¹⁰⁹ SS-3 (Mehedi), [115].

1. Training to use the Mixer Machine

60 As stated at [53] above, Imam was initially in charge of operating the Mixer Machine at the Tuas Site workshop, with Shohel and Mehedi assisting him. Imam had learned how to operate the Mixer Machine from Chua XD, who taught Imam how to make fire clay with the Mixer Machine by verbally telling Imam what to do. This teaching was done without any reference to a manual or other written instructions,¹¹⁰ in the course of a three to four hour long session in a single day.¹¹¹ Apart from Imam, Chua XD also taught Moe how to use the Mixer Machine, likewise without any reference to any user guide or other written manual.¹¹²

61 Chua XD had himself learned how to operate the Mixer Machine from a Ms Sherry Wang (“**Sherry**”) of Laizhou Keda over a phone call, sometime in June 2020. Sherry had taught Chua XD that the Mixer Machine was basically operated by pressing the buttons on its control panel, and that he was to follow the User Guide.¹¹³

¹¹⁰ SS-2 (Imam), [27].

¹¹¹ SS-3 (Mehedi), [29].

¹¹² SS-7 (Moe), [18].

¹¹³ SS-6 (Chua XD), [69].

62 A number of other Stars workers were also taught later how to operate the Mixer Machine:¹¹⁴

(a) Mehedi (see [53] above) was taught by Imam how to open the cover/lid of the Mixer Machine, tilt the Mixer Machine, start and stop the mixing function, and switch on and off the heaters using the buttons on the control panel. Apart from that, he did not receive any other training in respect of how to operate the Mixer Machine. Mehedi did not know, for example, whether the Mixer Machine was supposed to be stopped when it reached a certain temperature.¹¹⁵

(b) When Anis took over Imam as the worker in-charge at the Tuas Site workshop (see [55] above), Moe shared the fire clay formula with Anis and briefed him on how to use the Mixer Machine.¹¹⁶

(c) Moe also taught Marimuthu how to use the Mixer Machine and the formula for making fire clay when Marimuthu joined the Tuas Site workshop in January 2021 (see [55] above). Moe explained at the Inquiry hearing that he had taught Marimuthu the “practical steps” for operating the Mixer Machine, namely how to switch the heaters and the isolator on and

¹¹⁴ SS-6 (Chua XD), [69].

¹¹⁵ SS-3 (Mehedi), [30].

¹¹⁶ SS-7 (Moe), [64].

off, and to put water and the ingredients into the mixing chamber.¹¹⁷ He did not, however, teach Marimuthu any safety checks in relation to the use of the Mixer Machine, such as checking the level of oil in the Mixer Machine's oil jacket.¹¹⁸

2. Ventilation and dust conditions at the workshop

63 The workers' evidence was that when the Mixer Machine was in operation, the front shutters and back door were kept open for ventilation, while the windows were left partially open. The two fans at the workshop (a wall fan and a standing fan) would be switched on during work, though the wall fan would be temporarily switched off when the workers were weighing out the powders.¹¹⁹ The wall fan would blow air in the direction of the Platform and the standing fan would blow air in the direction of the assembly tables.¹²⁰ The workshop also had an exhaust vent, located near the ceiling.¹²¹ The exhaust vent was not placed above the Mixer Machine and served only to facilitate general ventilation at the workshop.¹²² It is not disputed that the exhaust vent was not used at the workshop before February 2021 as it was not working until Murugan repaired it on 15 February 2021, on Chua

¹¹⁷ NE 30 September 2021, p. 8:6-22 (Moe EIC).

¹¹⁸ NE 30 September 2021, pp. 9:1-10:1 (Moe EIC).

¹¹⁹ NE 21 September 2021, p. 68:7-17 (Mehedi EIC).

¹²⁰ NE 30 September 2021, pp. 13:20-15:3 (Moe EIC).

¹²¹ SS-6 (Chua XD), [35].

¹²² NE 30 September 2021, p. 16:3-17 (Moe EIC).

XD's instructions.¹²³ After it was repaired, the exhaust vent was used at the workshop.¹²⁴

64 The working areas at the workshop, including the area around the Mixer Machine, were generally dusty with powders on the floor.¹²⁵ At the end of each working day, the workers would do housekeeping. This primarily involved picking up and disposing of big items lying on the floors, and also sweeping with brooms.¹²⁶ We comment further on the issue of dust at the workshop at [409]-[412] below.

3. *Safety briefings*

65 The workers testified that they were not given any specific safety briefings for their work at the Tuas Site workshop.¹²⁷ While they did undergo general safety briefings that were conducted for all Stars' employees each month on salary collection day, these safety briefings covered safety measures to be adopted while working at clients' project sites (*ie*, construction sites) – for example, safety measures on working safely at height and carrying heavy objects. The workers thus

¹²³ SS-5 (Murugan), [37].

¹²⁴ SS-3 (Mehedi), [111] and [117].

¹²⁵ SS-10 (Yousuf), [52]; SS-11 (Rahad), [54]; SS-12 (Lizon), [47]; NE 21 September 2021, pp. 69:20-70:12 (Mehedi EIC); NE 28 September 2021, pp. 32:17-33:10 (Jitu EIC).

¹²⁶ SS-10 (Yousuf), [54]; SS-11 (Rahad), [55]; SS-12 (Lizon), [49]; NE 21 September 2021, pp. 70-71 (Mehedi EIC); NE 28 September 2021, pp. 34:1-35:14 (Jitu EIC).

¹²⁷ SS-10 (Yousuf), [55]; SS-11 (Rahad), [57]; SS-12 (Lizon), [51]; NE 21 September 2021, p. 72:12-23 (Mehedi EIC); NE 28 September 2021, p. 20:10-13 (Jitu EIC).

did not think that these safety briefings/measures were applicable to their work at the Tuas Site workshop, which was a factory environment/production workshop.¹²⁸

4. *Attire at the workshop*

66 While Imam, Anis, Shohel, Mehedi and Marimuthu were issued respirators for their work at the Tuas Site workshop, the additional workers who joined the fire wrap production team at the Tuas Site in February 2021 were not given respirators, and wore cloth face masks instead.¹²⁹

67 The workers' evidence was that they were not given a specific dress code for work at the workshop,¹³⁰ apart from Chua XD's instructions and reminders that they were to wear their safety shoes and respirators when making fire wrap.¹³¹

68 The workers mostly wore long-sleeved shirts to work at the Tuas Site workshop, and many of them wore slippers. Some also wore short-sleeved shirts and three-quarter pants.¹³²

¹²⁸ SS-10 (Yousuf), [56]; SS-11 (Rahad), [58]; SS-12 (Lizon), [52]; NE 28 September 2021, pp. 20:14-21:9 (Jitu EIC).

¹²⁹ SS-10 (Yousuf), [57]-[58]; SS-11 (Rahad), [62]; SS-12 (Lizon), [54].

¹³⁰ SS-10 (Yousuf), [57]; SS-11 (Rahad), [60]; SS-12 (Lizon), [53].

¹³¹ SS-3 (Mehedi), [36]; SS-11 (Rahad), [64]; SS-12 (Lizon), [57].

¹³² NE 21 September 2021, p. 75:14 (Mehedi EIC).

5. *Workload and working hours*

69 From 18 February 2021, the production target set by Chua XD was to produce 32 rolls of fire wrap per day, with each of the two assembly tables assigned a daily target of 16 rolls. To achieve this target, the workers would need to make two fresh batches of fire clay each day to use (taking into account also any leftover fire clay from the working day before).¹³³ The workers testified that they had to work from 8am in the morning until around 8:30-9:30pm at night, with an hour-long lunch break in between, to hit this target.¹³⁴

III. CHRONOLOGY OF KEY EVENTS

70 We now turn to the key events leading up to, and including, the Accident.

A. 12 June 2020 – Stars installed and commissioned the Mixer Machine

71 As explained above at [41], the Mixer Machine was installed at the Tuas Site workshop on 12 June 2020.¹³⁵

72 Following installation, the Mixer Machine was turned on and allowed to run as part of Stars' testing and commissioning of the Mixer Machine.¹³⁶ According to

¹³³ NE 21 September 2021, p. 99: 10-22 (Mehedi Re-ex).

¹³⁴ SS-3 (Mehedi), [116]; NE 28 September 2021, p. 36:3-14 (Jitu EIC); S-255 and S-285 (Timesheets for Stars workers at the Tuas Site).

¹³⁵ SS-6 (Chua XD), [56]; SS-2 (Imam), [16].

¹³⁶ SS-6 (Chua XD), [58].

Chua XD, the testing and commissioning of the Mixer Machine involved checks on the following:¹³⁷

- (a) motor direction;
- (b) presence of vibrations;
- (c) presence of any unusual sounds;
- (d) proper working of the hydraulic arm (for the cover of the mixing chamber of the Mixer Machine), tilting function of the mixing chamber, heating function, temperature sensor, emergency button and Drain Pipe;
- (e) the hydraulic oil and gear box oil; and
- (f) ensuring that there was no overloading of the voltage.

73 As part of the commissioning on 12 June 2020, Stars also did one round of testing by making fire clay with a small amount of raw materials.¹³⁸ For this test round, Stars mistakenly used water in the Mixer Machine's oil jacket.¹³⁹ According to Chua XD, he filled about "*half*" of the oil jacket with water, corresponding to the

¹³⁷ SS-6 (Chua XD), [58].

¹³⁸ SS-6 (Chua XD), [59].

¹³⁹ SS-6 (Chua XD), [60]; SS-2 (Imam), [20]; NE 30 September 2021, p. 27:20-25 (Moe EIC).

black marking made by Chua XD as shown in the photograph below.¹⁴⁰ He claimed that his black marking in the photograph also represented his understanding of “half-height” of the oil jacket, which was synonymous to him with the User Guide’s reference¹⁴¹ to “*half the height of the cylinder*”.¹⁴²



S-282: Copy of the photograph at CXD-63 with Chua XD’s indication in black of half-height of the oil jacket, which is synonymous (to him) with half-height of the cylinder

¹⁴⁰ NE 23 September 2021, pp. 135:11-137:9 (Chua XD EIC); S-282.

¹⁴¹ S-271, p. 5, Section Ten: The oil quantity in relation to the kneader jacket is stated as “*When refueling, you need to open one side vent hole and add it to half the height of the cylinder.*”

¹⁴² NE 23 September 2021, pp. 138:1-139:17 (Chua XD EIC).

74 Chua XD explained that he chose to fill the oil jacket up to that level because the water he had poured into the mixing chamber had also come up to that level.¹⁴³ On why he had filled the oil jacket with water, Chua XD said he assumed that water could be used as the heating medium in the oil jacket.¹⁴⁴

75 Chua XD did not note any issues in the making of the fire clay when water was used in the oil jacket.¹⁴⁵ However, he noticed that there was a lot of steam generated when the Mixer Machine's heaters were on. He was also concerned whether the water boiling temperature of only 100°C would mean a longer "cooking" time when making a larger batch of fire clay.¹⁴⁶ This prompted Chua XD to check the User Guide¹⁴⁷ and he realised that oil should be used in the oil jacket.¹⁴⁸ He then contacted Laizhou Keda (Sherry) via WhatsApp on 12 June 2020 afternoon asking whether he could use water instead of oil in the oil jacket. Laizhou Keda advised him that he should use heat transfer oil in the oil jacket as water could damage the heaters.¹⁴⁹

¹⁴³ NE 23 September 2021 pp. 141:10-143:8 (Chua XD EIC).

¹⁴⁴ SS-6 (Chua XD), [60].

¹⁴⁵ SS-6 (Chua XD), [61].

¹⁴⁶ SS-6 (Chua XD), [61].

¹⁴⁷ S-271.

¹⁴⁸ SS-6 (Chua XD), [61].

¹⁴⁹ SS-6 (Chua XD), [61]; S-2, IM#146-152.

76 During the commissioning on 12 June 2020, the Back Pipe was open, and the Mixer Machine was used as an open system.¹⁵⁰

B. 16 June 2020 – Stars/Chua XD purchased 2 buckets of oil for the oil jacket

77 Following Laizhou Keda's advice, Stars/Chua XD purchased 2 buckets of oil (20L each) from MHT on 16 June 2020.¹⁵¹ Both buckets (*ie*, 40L) were poured into the oil jacket that same day.¹⁵²

78 Thereafter, the Mixer Machine was used to make fire clay at least three times from 16 June 2020 to before 7 August 2020.¹⁵³

C. 7 August 2020 – Imam observed that oil was running out in the oil jacket and reported it to Chua XD

79 At about 11pm on 7 August 2020, Moe instructed Imam to make a batch of fire clay in preparation for making fire wrap the next day.¹⁵⁴ While operating the Mixer Machine that night, Imam suspected that the oil in the Mixer Machine's oil

¹⁵⁰ NE 24 September 2021 pp. 1:2-3:8 (Chua XD EIC).

¹⁵¹ SOAF, [22(a)]; SS-17 (Sharon), [3(a)].

¹⁵² SS-6 (Chua XD), [65].

¹⁵³ SS-6 (Chua XD), [121].

¹⁵⁴ SS-6 (Chua XD), [36].

jacket was running out.¹⁵⁵ Slightly past midnight, Imam sent a WhatsApp message to Chua XD informing him that there was no more oil in the oil jacket.¹⁵⁶ Imam also sent a video to Chua XD of Nasim checking the oil level in the Mixer Machine's oil jacket using a dipstick.¹⁵⁷ In the video, Imam can be heard explaining that there was very little oil left in the oil jacket and that there was no more oil at the workshop to top up the oil jacket.¹⁵⁸ The dipstick indicated the oil fill level to be about one and half inches from the bottom of the oil jacket.¹⁵⁹

80 In response to Chua XD's query on where all the oil had gone, Imam explained that all the oil had been used up after four times of making fire clay using the Mixer Machine.¹⁶⁰ Chua XD then instructed Imam to close all the openings of the oil jacket (*ie*, the Back Pipe and the Front Pipe), explaining “[*i*]f not all the oil gone already”.¹⁶¹ In particular, the Mixer Machine had come with the Front Pipe closed with an end cap provided by Laizhou Keda (see [39(c)]) and Chua XD wanted Imam to additionally close the Back Pipe.¹⁶² Chua XD was concerned about the evaporation of the oil from the Front Pipe and Back Pipe.¹⁶³

¹⁵⁵ SS-2 (Imam), [36].

¹⁵⁶ SS-2 (Imam), [36]; SS-6 (Chua XD), [120].

¹⁵⁷ S-151.

¹⁵⁸ SS-2 (Imam), [37]; SS-6 (Chua XD), [120].

¹⁵⁹ NE 23 September 2021 pp. 159:2-160:7 (Chua XD EIC).

¹⁶⁰ SS-2 (Imam), [38]; SS-6 (Chua XD), [121].

¹⁶¹ SS-2 (Imam), [38]; SS-6 (Chua XD), [122].

¹⁶² SS-6 (Chua XD), [123].

¹⁶³ NE 24 September 2021 pp. 32:14-33:12 (Chua XD EIC).

81 Shortly after, at 12:37am on 8 August 2020, Chua XD made an order for 4 buckets of thermic oil (20L each) from MHT via WhatsApp.¹⁶⁴

D. 8 August 2020 – Imam replaced a burned heater on Chua XD’s instructions

82 Even though there was very little oil left in the oil jacket the night before, Imam started making a batch of fire clay on the morning of 8 August 2020 with Shohel.¹⁶⁵ No one had instructed Imam not to use the Mixer Machine pending the addition of more oil.¹⁶⁶ While the Mixer Machine was in operation that morning, a spark and smoke came out from Heater No. 1.¹⁶⁷

83 Imam immediately turned off the Mixer Machine by pressing the red Emergency Stop button on the Mixer Machine's control panel and contacted Chua XD.¹⁶⁸ Following Chua XD’s instructions, Imam waited for the Mixer Machine to cool down. Shohel and he then drained out the used oil in the oil jacket, which came to about 1½ 20L buckets.¹⁶⁹ The colour of the used oil was observed to be reddish-black.¹⁷⁰

¹⁶⁴ SS-6 (Chua XD), [65]; S-5, IM#38-39.

¹⁶⁵ SS-2 (Imam), [42].

¹⁶⁶ NE 20 September 2021, p. 124:11-16 (Imam EIC).

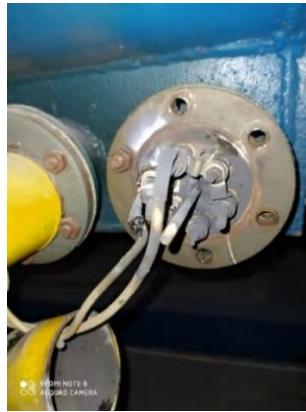
¹⁶⁷ SS-2 (Imam), [42].

¹⁶⁸ SS-2 (Imam), [43].

¹⁶⁹ SS-2 (Imam), [43(a)].

¹⁷⁰ SS-2 (Imam), [54].

84 Over a video call, Chua XD gave Imam instructions on how to replace the damaged heater with one of the spare heaters that had come with the Mixer Machine.¹⁷¹ Imam updated Chua XD after he had replaced the damaged heater and sent photographs of the damaged heater to Chua XD:¹⁷²



S-6: Photograph of damaged Heater No. 1, sent by Imam to Chua XD on 8 August 2020, 9:30am



S-6: Photograph of damaged Heater No. 1, sent by Imam to Chua XD on 8 August 2020, 9:40am

¹⁷¹ SS-6 (Chua XD), [126].

¹⁷² SS-2 (Imam), [44]-[45]; SS-6 (Chua XD), [127]-[129]; S-6.

85 As shown in the photograph above of the heating rods of the damaged Heater No. 1, one of the heating rods had deformed from burning and was exposing the interior of the heating rod.¹⁷³

86 Imam had also sent the photograph above of the heating rods of the damaged Heater No. 1 to Moe that same morning at 9:32am.¹⁷⁴ Moe did not get involved in the replacement of the damaged heater and he left it to Imam to discuss the matter directly with Chua XD.¹⁷⁵

87 After Imam had replaced the damaged Heater No.1, Chua XD visited the Tuas Site workshop to check on the replaced heater.¹⁷⁶ According to Chua XD, when he was at the workshop, Imam checked the voltage, continuity, resistance, and earth leakage on all the heaters to ensure there was no earth leakage, and they also checked all the heaters and the cables with a megohmmeter.¹⁷⁷

¹⁷³ SS-2 (Imam), [45]; SS-6 (Chua XD), [129].

¹⁷⁴ SS-2 (Imam), [47]; SS-7 (Moe), [36].

¹⁷⁵ SS-7 (Moe), [37]-[39].

¹⁷⁶ SS-2 (Imam), [45]; SS-6 (Chua XD), [130].

¹⁷⁷ SS-6 (Chua XD), [130].

E. 8 August 2020 – Stars/Chua XD purchased 4 buckets of oil for the oil jacket

88 As explained above at [81], on 8 August 2020, Stars/Chua XD purchased 4 buckets of thermic oil (20L each) from MHT.¹⁷⁸ They were delivered to the Tuas Site that day, after the incident involving the damaged Heater No. 1. Imam then poured into the oil jacket 3 new buckets of oil and the 1½ buckets of used oil that had been drained out in the morning.¹⁷⁹ Imam was not given any instructions on how much oil to pour into the oil jacket.¹⁸⁰

89 According to Imam, he added oil from the fourth new bucket into the oil jacket later in August 2020.¹⁸¹ According to Chua XD, he added oil incrementally thereafter during his monthly maintenance checks of the Mixer Machine.¹⁸² No new buckets of oil were purchased by Stars until 5 February 2021¹⁸³ (see [123] below).

¹⁷⁸ SOAF, [22(b)].

¹⁷⁹ SS-2 (Imam), [54].

¹⁸⁰ SS-2 (Imam), [54].

¹⁸¹ SS-2 (Imam), [55].

¹⁸² SS-6 (Chua XD), [66].

¹⁸³ SOAF, [22(c)].

F. From 8 August 2020 onwards – Imam closed the Front Pipe and Back Pipe of the oil jacket on Chua XD’s instructions

90 Pursuant to the instructions given by Chua XD in the wee hours of 8 August 2020 (see [80] above) and further clarifications from Chua XD on how to close the Back Pipe,¹⁸⁴ Imam closed both the Front Pipe and Back Pipe openings. Imam had initially closed the Front Pipe with the end cap that it had come with (see [39(c)] above) and the Back Pipe with a “Bush” pipe fitting he had purchased.¹⁸⁵ Following further clarification from Chua XD, Imam subsequently closed the Back Pipe with another end cap he had sourced himself.¹⁸⁶

91 Except for a few brief occasions when oil was added to the oil jacket through the Back Pipe, the Front Pipe and Back Pipe remained closed thenceforth including during the operation of the Mixer Machine to make fire clay.¹⁸⁷

¹⁸⁴ SS-2 (Imam), [48]-[53]; SS-6 (Chua XD), [131]-[136].

¹⁸⁵ SS-2 (Imam), [52].

¹⁸⁶ SS-2 (Imam), [53].

¹⁸⁷ SS-6 (Chua XD), [137]; SS-7 (Moe), [25]; NE 20 September 2021, p. 149:20-2 (Imam, questions from IC).

G. 28 August 2020 – Stars’ workers observed smoke from the oil jacket, black oil with sediments and deteriorated heater gaskets, and these were reported to Moe and Chua XD

92 In the morning of 28 August 2020, Imam noticed that the Mixer Machine was taking about an hour longer than usual to heat the water up to 90°C to make fire clay.¹⁸⁸ He also observed that there was smoke coming out from the area where the Mixer Machine’s heaters were located. Imam testified that this smoke had an “oil burning smell”.¹⁸⁹ Imam turned off the Mixer Machine and checked on the heaters.¹⁹⁰

93 Imam reported the matter to Moe but Moe told Imam to report the matter to Chua XD instead.¹⁹¹ Imam tried to call Chua XD but was unable to reach him.¹⁹²

94 Imam, Mehedi and Shohel drained out the oil from the oil jacket to check the Mixer Machine’s heaters. Imam took a video of the oil being drained and sent it to Moe.¹⁹³ About 6 buckets of oil were drained out.¹⁹⁴ The 4 white-coloured

¹⁸⁸ SS-2 (Imam), [63].

¹⁸⁹ NE 20 September 2021, pp. 127:12-128:3 (Imam EIC).

¹⁹⁰ SS-2 (Imam), [63].

¹⁹¹ SS-2 (Imam), [63]-[64]; SS-7 (Moe), [41]-[42].

¹⁹² SS-2 (Imam), [65].

¹⁹³ SS-2 (Imam), [68]; SS-7 (Moe), [45]; S-156.

¹⁹⁴ SS-2 (Imam), [68].

buckets seen in the video were the original 20L buckets that the oil had come in.¹⁹⁵ From the video, it can be seen that none of the 6 buckets (into which the oil was drained) was full. Mehedi observed that the drained oil was black in colour, and that there were black sediments in the oil.¹⁹⁶ Moe told Imam to send the video to Chua XD,¹⁹⁷ but Imam did not do so. During this time, Imam was checking the heaters by doing a visual check and performing a megger test.¹⁹⁸

95 Imam and Mehedi also observed, when the heaters were removed, that the gaskets on the heater openings of the Mixer Machine's oil jacket were worn out.¹⁹⁹ According to Imam, parts of the gasket were stuck to the heater openings and he had to peel them off.²⁰⁰ According to Mehedi, some part of the gaskets had broken and fallen off, and he thought it could have been caused by the heat from the oil jacket surfaces where the gaskets were attached.²⁰¹

96 Imam called Chua XD again and managed to reach him. Imam informed Chua XD about the issue involving the Mixer Machine and updated Chua XD about the old worn-out gaskets.²⁰² Chua XD told Imam to replace all the old worn-out

¹⁹⁵ SS-3 (Mehedi), [57].

¹⁹⁶ SS-3 (Mehedi), [57] and [61].

¹⁹⁷ SS-2 (Imam), [69]; SS-7 (Moe), [45].

¹⁹⁸ SS-2 (Imam), [71].

¹⁹⁹ SS-2 (Imam), [72]; SS-3 (Mehedi), [58].

²⁰⁰ NE 20 September 2021, p. 128:4-23 (Imam EIC).

²⁰¹ NE 21 September 2021, p. 61:1-12 (Mehedi EIC).

²⁰² SS-2 (Imam), [72].

gaskets with new gaskets²⁰³ and instructed Imam to ask Nasim to make the new gaskets.²⁰⁴ Mehedi and Shohel replaced the old gaskets with new ones that Nasim made that day at the workshop.²⁰⁵ Thereafter, Imam re-installed all the heaters.²⁰⁶ The drained oil, less the heavier black sediments which had settled at the bottom of the buckets, was poured back into the oil jacket.²⁰⁷ According to Imam, he did not recall any issues with the heaters when he used the Mixer Machine the next day.²⁰⁸

H. 21 September 2020 – Imam observed smoke from the oil jacket and reported it to Moe

97 When Imam was operating the Mixer Machine on 21 September 2020, he noticed something like smoke or oil vapour coming out from the bottom of the oil jacket at the back of the Mixer Machine (near the heaters).²⁰⁹ Imam took a video of it and sent it to Moe that morning.²¹⁰ Imam checked with Moe via WhatsApp if he and Chua XD knew about the issue and if there were any concerns.²¹¹ Moe replied that it was normal for the smoke that Imam saw to come from the heaters and that

²⁰³ SS-2 (Imam), [72]; NE 24 September 2021, pp. 112:24-113:21 (Chua XD EIC).

²⁰⁴ SS-2 (Imam), [72].

²⁰⁵ SS-2 (Imam), [72]; SS-3 (Mehedi), [59]; SS-4 (Nasim), [47].

²⁰⁶ SS-2 (Imam), [74]; SS-3 (Mehedi), [59].

²⁰⁷ SS-3 (Mehedi), [61].

²⁰⁸ SS-2 (Imam), [74].

²⁰⁹ SS-2 (Imam), [75].

²¹⁰ SS-2 (Imam), [76]; SS-7 (Moe), [50]; S-157.

²¹¹ SS-2 (Imam), [76]; SS-7 (Moe), [50].

this was not a problem.²¹² According to Moe, Chua XD had previously told him that there was nothing to be concerned about as it was just hot vapour from the oil jacket's hot surface.²¹³

98 This was not the first or last time that smoke was seen coming from the oil jacket. Moe had first noticed the smoke sometime in August or September 2020. He had seen the smoke coming out from the bottom corners of the oil jacket when the heaters were turned on and he observed that the smoke lasted for about five minutes, before it was time to switch off the heaters.²¹⁴ Subsequently, each time the heaters were turned on to heat the water, Stars' workers would observe white smoke in the last five minutes before they switched off the heaters.²¹⁵ Moe explained that they observed this through to February 2021, although as explained below at [120], the white smoke became heavier from 8 January 2021.²¹⁶

I. 28 September 2020: Imam discovered a leak in the oil jacket and the leak was reported to Moe and Chua XD

99 On 28 September 2020, when Imam was operating the Mixer Machine, he heard boiling sounds from inside the oil jacket and saw oil leaking from what

²¹² SS-2 (Imam), [76]; SS-7 (Moe), [50].

²¹³ SS-7 (Moe), [50].

²¹⁴ SS-7 (Moe), [49].

²¹⁵ SS-7 (Moe), [51].

²¹⁶ SS-7 (Moe), [51].

appeared to be a small hole on the surface of the oil jacket.²¹⁷ This was at the front bottom left corner of the Mixer Machine.²¹⁸

100 Imam took a photograph of the oil jacket, circled in blue the location of the small hole where oil was leaking and sent the photograph to Moe that morning with the accompanying messages: “hole have small” and “need to welding bro”.²¹⁹



S-52: Photograph sent by Imam to Moe on 28 September 2020, 10:25am

²¹⁷ SS-2 (Imam), [79].

²¹⁸ SS-2 (Imam), [79].

²¹⁹ SS-2 (Imam), [79]-[80]; SS-7 (Moe), [54]-[55]; S-11, IM#1358 and #1569; S-52.

101 Moe's instructions were to ask Nasim or Mehedi to do the welding, and Imam said he would keep Moe updated.²²⁰ Moe had not yet checked with Chua XD when he gave these instructions, but Nasim was the company welder and Mehedi helped Nasim on occasion.²²¹

102 Chua XD admitted that he was updated about the leak by late September 2020,²²² and according to Moe, Chua XD had agreed with Moe that Nasim should do the welding.²²³

103 Mehedi had also seen the small hole and leak that day on 28 September 2020 and he had been told by Imam that Moe had been updated.²²⁴ According to Mehedi, Imam had asked him if he could weld the leak close, but he had told Imam that he did not know how to weld it.²²⁵ Imam also asked Nasim to do the welding but according to Nasim, he had told Imam that he was unable to weld the Mixer Machine unless Chua XD expressly gave him instructions to do so.²²⁶

²²⁰ SS-7 (Moe), [55].

²²¹ SS-7 (Moe), [55].

²²² SS-6 (Chua XD), [148]; NE 27 September 2021, p. 158:3-6 (Chua XD EIC).

²²³ SS-7 (Moe), [55].

²²⁴ SS-3 (Mehedi), [62].

²²⁵ SS-3 (Mehedi), [63].

²²⁶ SS-4 (Nasim), [49].

104 On 30 September 2020, Imam updated Moe that Nasim was unable to help with the welding and that they should try to resolve the problem soon. They had the following exchange on WhatsApp regarding the issue.²²⁷

Imam: *“need to welding bro nasim say can't”*

Imam: *“now small. hole”*

Imam: *“later big hole”*

Moe: *“Just tell him”*

Imam: *“ok”*

Moe: *“If now no settle”*

Moe: *“Later problem can u answer”*

Moe: *“Said like this”*

Imam: *“yesterday i talk to hin radet”*

Imam: *“he say can't”*

Imam: *“no problem”*

Imam: *“tommrow mahadi welding”*

105 Notwithstanding the above exchange, neither Imam nor Moe spoke to Mehedi or Nasim again about the welding.²²⁸

²²⁷ S-11, IM#3591-3602.

²²⁸ SS-2 (Imam), [83]; SS-7 (Moe), [57].

106 On 2 October 2020, Chua XD carried out his monthly maintenance check on the Mixer Machine. Yet, he did not indicate the presence of the leak in the maintenance checklist (inaccurately dated 2 October 2020),²²⁹ despite having been updated about the leak in late September 2020 (see [102] above).

107 No welding was done on the Mixer Machine's oil jacket until 12 October 2020 when the leak became worse.²³⁰

J. 1 October 2020 – Stars' workers observed drained black oil with black sediments inside

108 On 1 October 2020, the oil in the oil jacket was drained out by Mehedi and Shohel on Imam's instructions.²³¹ Mehedi and Shohel drained out oil that filled a total of 4 oil buckets (20L each), 1 plastic bucket, and 1 smaller metal bucket.²³²

²²⁹ NE 27 September 2021, pp. 77:22-79:19 (Chua XD XX); S-245 (Maintenance checklist).

²³⁰ SS-3 (Mehedi), [63]; SS-2 (Imam), [83]; SS-7 (Moe), [57]; SS-6 (Chua XD), [149].

²³¹ SS-3 (Mehedi), [64]; SS-2 (Imam), [85].

²³² SS-3 (Mehedi), [65].

109 Mehedi took a photograph of the oil that been drained and sent it to the WhatsApp group chat called “SHIELD+Daily reporting gp”, whose members included Anis, Nasim, Shohel, Imam, and Marimuthu.²³³



S-284: Photograph of the oil drained out by Mehedi and Shohel on 1 October 2020

110 Shortly after, Imam forwarded the same photograph to the “SHIELD+TEAM” WhatsApp chat group (“Shield+ WhatsApp Chat”), whose members included Moe and Chua XD.²³⁴

²³³ SS-3 (Mehedi), [65]; NE 21 September 2021, p. 5:2-14 (Mehedi EIC).

²³⁴ NE 30 September 2021, p. 40: 25-42:4 (Moe EIC).

111 It was observed that there were black sediments in the drained oil. The drained oil, less the black sediments which settled at the bottom of the buckets, was eventually poured back into the oil jacket later that day.²³⁵

K. 12 October 2020 – Stars’ workers observed oil leaking from the oil jacket again and the leak was reported to Moe and Chua XD

112 On 12 October 2020 morning, despite the oil jacket leak discovered on 28 September 2020 not having been repaired, Stars’ workers operated the Mixer Machine to make fire clay.

113 When operating the Mixer Machine, Mehedi noticed smoke and oil coming out from the oil jacket.²³⁶ The location was at the front bottom left of the oil jacket which was where oil had leaked from on 28 September 2020 (see [99] above).²³⁷ By this time, the area of the leak had grown.²³⁸

114 Mehedi took a video of the leak, circled in green the location of the leak and sent the video to Moe that morning at 8:55am and informed that oil was leaking

²³⁵ SS-3 (Mehedi), [66].

²³⁶ SS-3 (Mehedi), [68]-[70].

²³⁷ SS-3 (Mehedi), [70].

²³⁸ SS-3 (Mehedi), [70]

from the oil jacket.²³⁹ In the video, white smoke can be seen spurting out from the location of the leak, and a hissing and crackling sound can be heard.²⁴⁰

115 Moe thought that the white smoke seen in the video was oil vapour coming out of the crack in the oil jacket.²⁴¹

116 Moe replied to Mehedi that Chua XD had asked Mehedi to weld the area of the leak.²⁴² Mehedi replied that Nasim would do the welding that day.²⁴³ Chua XD had also seen Mehedi's video that day and he also instructed Nasim to do the welding.²⁴⁴ However, Chua XD did not visit the Tuas Site workshop to physically inspect the leak.²⁴⁵ Chua XD also did not think of checking with Laizhou Keda on the leak.²⁴⁶

²³⁹ SS-3 (Mehedi), [71]; S-13; S-158.

²⁴⁰ NE 24 September 2021, pp. 42:8-43:13 (Chua XD EIC); S-158.

²⁴¹ NE 30 September 2021, pp. 42:8-43:15 (Moe EIC).

²⁴² SS-3 (Mehedi), [71]; SS-7 (Moe), [60].

²⁴³ SS-3 (Mehedi), [72].

²⁴⁴ SS-6 (Chua XD), [150]-[151].

²⁴⁵ SS-6 (Chua XD), [152]; NE 24 September 2021, pp. 68:24-70:19 (Chua XD EIC).

²⁴⁶ SS-6 (Chua XD), [152].

117 On the same day, Mehedi asked Nasim to do the welding.²⁴⁷ On or about 12 October 2020, Nasim did the welding with Mehedi's help.²⁴⁸ According to Nasim in his witness statement, he:²⁴⁹

- (a) Ground away/removed the paint covering the leak area;
- (b) Ground away part of the manufacturer's original weldment at the leak area;
- (c) Identified a 3mm long hairline crack on the manufacturer's original weldment;
- (d) Ground a further groove along the hairline crack to create more space/depth to fill with fresh weld metal. The groove that he created was much larger than the 3mm hairline crack as the grinder he used had a fixed 100mm diameter and was unable to grind anything shorter than around 50mm; and
- (e) Finally, filled the groove with three to four layers of fresh welding.

118 However, Nasim later walked back on this account, stating in oral evidence that all he did was to remove the paint before welding directly onto the old

²⁴⁷ SS-3 (Mehedi), [72].

²⁴⁸ SS-3 (Mehedi), [73]; SS-4 (Nasim), [50].

²⁴⁹ SS-4 (Nasim), [51]-[52].

weldment.²⁵⁰ This is consistent with Matcor's observations on the lack of preparation observed, and that the repair welds were done over the existing welds.²⁵¹

L. 8 January 2021 – Moe observed smoke from the oil jacket's bottom corners and reported it to Chua XD

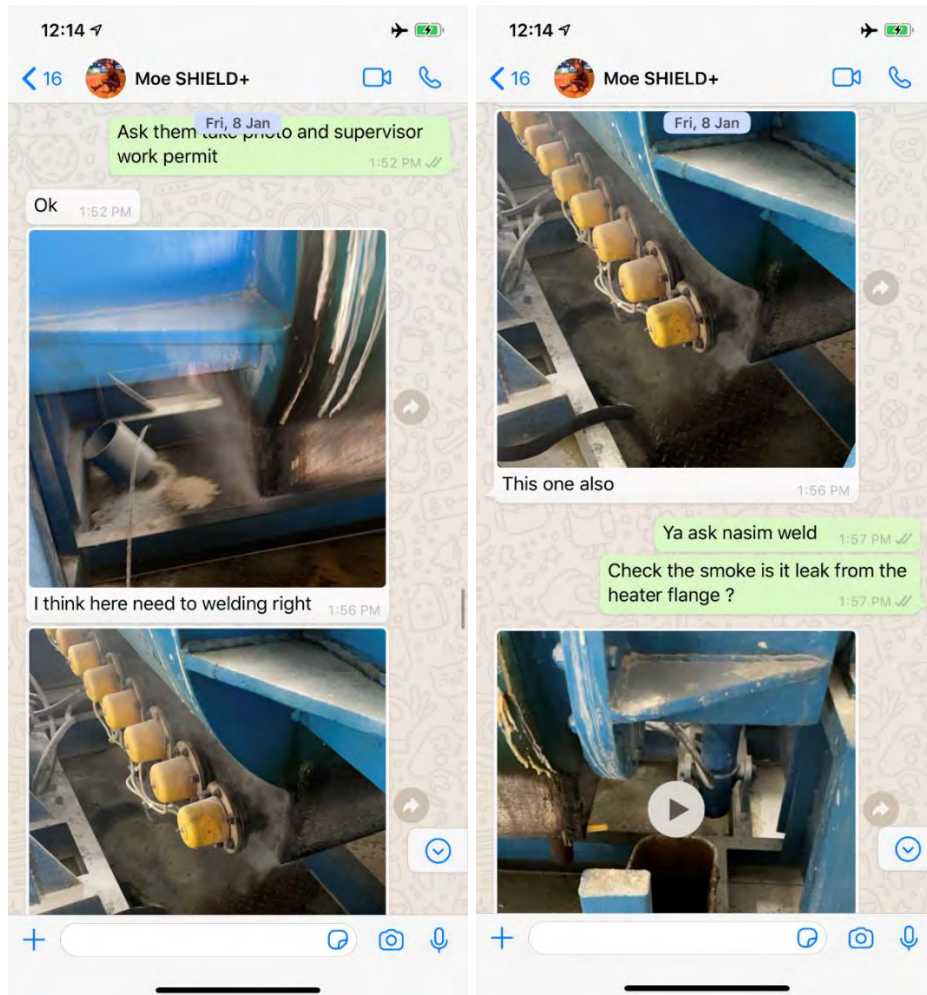
119 On 8 January 2021, Moe was at the Tuas Site workshop, when he noticed white smoke coming out from the bottom corners of the Mixer Machine's oil jacket when the Mixer Machine's heaters were turned on to heat the water in the mixing chamber.²⁵² He sent photographs of the front bottom left corner and back bottom right corner of the oil jacket to Chua XD via WhatsApp at 1:56pm and suggested that welding should be done:²⁵³

²⁵⁰ NE 22 September 2021, p. 61:8-17 (Nasim EIC).

²⁵¹ NE 4 October 2021, p. 37:13-22 (Matcor EIC).

²⁵² SS-7 (Moe), [66].

²⁵³ SS-7 (Moe), [67]; S-14.



S-14: Photographs sent by Moe to Chua XD on 8 January 2021 at 1:56pm

120 Moe observed that the white smoke was a lot heavier than on previous occasions (see [98] above), and lasted about ten minutes before it was time to switch off the heaters.²⁵⁴ Moe thought that the white smoke was oil vapour and that it was

²⁵⁴ SS-7 (Moe), [67].

coming out from cracks in the oil jacket's bottom corners.²⁵⁵ Moe thought that the white smoke coming out from the oil jacket indicated that something was not safe about the Mixer Machine.²⁵⁶

121 Chua XD replied that Moe should ask Nasim to weld.²⁵⁷ He also asked that Moe check whether the smoke was leaking from the heater flanges.²⁵⁸ Moe checked and reported to Chua XD that the smoke was coming not from the heater flanges but from three corners of the oil jacket (front bottom right corner, front bottom left corner and back bottom right corner). Moe took a video showing the smoke at all three corners and sent it to Chua XD at 1:57pm.²⁵⁹

122 Ultimately, no welding was done to the oil jacket until after the fire on 12 February 2021 (see [150] below).²⁶⁰ In the meantime, and until 12 February 2021, each time the Mixer Machine's heaters were turned on to heat the water, the Stars workers would observe white smoke from the bottom corners of the Mixer Machine's oil jacket in the last ten minutes before it was time to switch off the heaters.²⁶¹

²⁵⁵ NE 30 September 2021, pp. 46:24-48:3 (Moe EIC); SS-7 (Moe), [67].

²⁵⁶ NE 30 September 2021, pp. 49:17-50:1 (Moe EIC).

²⁵⁷ SS-7 (Moe), [68].

²⁵⁸ SS-7 (Moe), [68].

²⁵⁹ SS-7 (Moe), [68]; S-159.

²⁶⁰ SS-7 (Moe), [70].

²⁶¹ SS-7 (Moe), [70].

M. 5 February 2021 – Stars/Chua XD purchased 4 buckets of oil for the oil jacket

123 On 5 February 2021, Stars/Chua XD purchased four buckets of oil (20L each) from MHT.²⁶² Of these, 2 unused buckets were found at the Tuas Site workshop on 27 May 2021, after the Accident. It is unknown to Chua XD what became of the other 2 buckets.²⁶³

N. 6 February 2021 – Stars’ workers installed insulation over the oil jacket on Chua XD’s instructions

124 On 6 February 2021, Stars workers installed insulation over the oil jacket. Chua XD had instructed them to do so to protect the workers from the hot surface of the oil jacket.²⁶⁴

125 The insulation comprised ceramic fibre which was white in colour with a layer of aluminium foil encasing it and taped down by aluminium tape.²⁶⁵ It was installed onto the surface of the oil jacket with small welding pins.²⁶⁶ The welding pins were tacked onto the surface of the oil jacket without penetrating the surface.²⁶⁷

²⁶² SOAF, [22(c)]; SS-17 (Sharon), [3(c)].

²⁶³ SS-6 (Chua XD), [67].

²⁶⁴ SS-6 (Chua XD), [157].

²⁶⁵ SS-6 (Chua XD), [157]; SS-7 (Moe), [90].

²⁶⁶ SS-6 (Chua XD), [157].

²⁶⁷ SS-6 (Chua XD), [157].

126 In particular, the insulation was installed over the oil jacket surfaces at the front of the Mixer Machine, the back of the Mixer Machine and underneath the Mixer Machine and covered the jacket temperature RTD fixtures.²⁶⁸



S-55: Photographs of the insulation on the oil jacket taken by Marimuthu on 6 February 2021

O. 12 February 2021 – Fire on the Mixer Machine

127 On 12 February 2021, the first day of Chinese New Year, at about 4:50pm, a fire broke out at the Mixer Machine.²⁶⁹ The fire was concentrated at the front bottom right corner of the Mixer Machine, and a flame front extended up the right side (when facing the front of the Mixer Machine):²⁷⁰



S-63: Photograph of the fire taken by Marimuthu on 12 February 2021

²⁶⁹ SOAF, [24].

²⁷⁰ S-63.

128 According to Mehedi, Marimuthu was first to notice the fire as he was operating the Mixer Machine on the Platform.²⁷¹ Mehedi himself was heading up the Platform at the time and was midway up the stairs when he noticed the fire.²⁷² He observed a red-orange flame measuring about 250-300mm high and 150-250mm wide.²⁷³

129 Mehedi and Marimuthu put out the fire with a hose reel, before Marimuthu turned off the Mixer Machine by hitting the Emergency Stop button on the control panel.²⁷⁴ When the fire had been put out, Mehedi noticed beads of black oil dripping down the front bottom right corner of the Mixer Machine and white smoke coming out from that same corner.²⁷⁵

130 Chua XD was not at the Tuas Site workshop that day, but he was updated via phone call at about 4:52pm.²⁷⁶ Shortly after, between 4:56pm and 4:57pm, Chua XD also received some photographs and a video in the Shield+ WhatsApp Chat, which showed that the workshop at the Tuas Site was filled with smoke.²⁷⁷ Mehedi had sent the photographs and video.²⁷⁸

²⁷¹ SS-3 (Mehedi), [88].

²⁷² SS-3 (Mehedi), [88].

²⁷³ SS-3 (Mehedi), [88].

²⁷⁴ SS-3 (Mehedi), [89].

²⁷⁵ SS-3 (Mehedi), [89].

²⁷⁶ SS-6 (Chua XD), [160]; SS-3 (Mehedi), [90].

²⁷⁷ SS-6 (Chua XD), [160]; S-18.

²⁷⁸ SS-3 (Mehedi), [91].

131 Chua XD subsequently sent, at 5:18pm, the following WhatsApp message to Marimuthu, Moe and the Shield+ WhatsApp Chat, instructing the workers on what to do:²⁷⁹

“1. All power & lighting off

2. Clear the smoke With the ventilation fan

3. Clean and wipe clean all water at level 1 and decking

4. Take off all the ceramic wrapping at the oil tank

5. Drain out all the oil when the machine cool down

6. Access which part of the mixer spoilt

7. Make sure the tank surface is cool then start full welding the oil leaking area”

132 Chua XD said he was panicking and thought that there was a crack on the Mixer Machine’s oil jacket, similar to the incident on 12 October 2020 (see [113]-[114] above).²⁸⁰ His immediate instinct was that oil was leaking out, which led to an oil fire on the oil jacket.²⁸¹ Hence, his instructions to weld the “*oil leaking area*” on the oil jacket.²⁸² Chua XD separately told Moe (who was not at the workshop that day) to ask Nasim to do the welding and Moe passed on the message to

²⁷⁹ S-17; S-19; S-18.

²⁸⁰ SS-6 (Chua XD), [163].

²⁸¹ NE 24 September 2021, p. 91:4-8 (Chua XD EIC).

²⁸² SS-6 (Chua XD), [163].

Marimuthu, explaining “*Muthu item no 7. ask nasim to do. Make sure all welding nicely*”.²⁸³ Chua XD also instructed Moe to update him later, on which parts of the Mixer Machine were spoilt and said that he would visit the workshop later that night to take a look at the Mixer Machine.²⁸⁴ Ultimately, however, Moe did not update Chua XD and Chua XD did not visit the workshop that night.²⁸⁵

133 Around this time, Chua XD also privately contacted Murugan (who was at Little India at that time) and asked him to go to the Tuas Site workshop to help the workers deal with the fire.²⁸⁶ Chua XD also wanted Murugan to specifically check whether the exhaust vent at the workshop was working as it appeared from Mehedi’s video of the smoke-filled workshop (see [130] above) that the smoke was not being vented out of the workshop by the exhaust vent.²⁸⁷

134 Murugan arrived at the Tuas Site workshop at about 5:45pm.²⁸⁸ He noticed that the entire workshop was filled with smoke.²⁸⁹ The Stars workers had gathered

²⁸³ SS-7 (Moe), [80].

²⁸⁴ SS-7 (Moe), [81]; SS-6 (Chua XD), [165].

²⁸⁵ SS-7 (Moe), [81]; SS-6 (Chua XD), [191].

²⁸⁶ SS-5 (Murugan), [12]; SS-6 (Chua XD), [164].

²⁸⁷ SS-6 (Chua XD), [164].

²⁸⁸ SS-5 (Murugan), [14].

²⁸⁹ SS-5 (Murugan), [14].

in the back alley outside the rear of the workshop.²⁹⁰ No one was hurt.²⁹¹ Murugan checked on the exhaust vent and found that it was not working.²⁹²

135 During this period, Chua XD was still texting Moe over WhatsApp about the incident. From 6:00pm to 6:09pm, Chua XD had the following exchange with Moe as Chua XD was concerned about the oil and the Mixer Machine:²⁹³

Chua XD: *“Moe can u ask oo to check with the supplier? Tell her we use the thermal oil catch fire”*

Chua XD: *“Do she have a better higher thermal grade oil?”*

Chua XD: *“I already send the enquiry to China to buy the full stainless steel mixer”*

Chua XD: *“Also use water to heat up instead of oil”*

Chua XD: *“U ask oo to check with the thermal oil supplier, we need high thermal flashpoint oil grade”*

Chua XD: *“This oil grade cannot, the heat we use is too high for the oil”*

Moe: *“Mixer machine supplier right?”*

²⁹⁰ SS-5 (Murugan), [14].

²⁹¹ SS-5 (Murugan), [14].

²⁹² SS-5 (Murugan), [15].

²⁹³ SS-6 (Chua XD), [168]; SS-7 (Moe), [83].

Moe: *“Ok”*

Moe: *“I ask oo oo to check”*

Chua XD: *“Mixer supplier I settle”*

Chua XD: *“U ask oo settle the thermal oil supplier”*

Chua XD: *“I need high thermal flash point grade oil”*

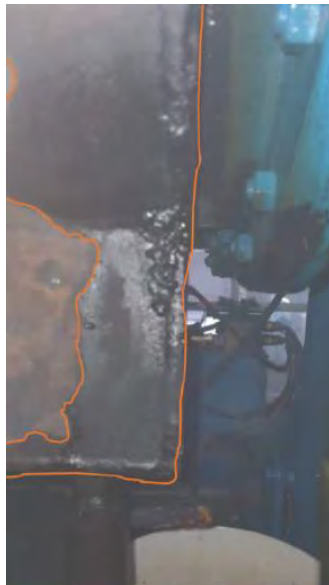
Moe: *“Ok”*

136 As regards the Mixer Machine, given the earlier incidents that had taken place, Chua XD no longer knew whether the Mixer Machine was still operational, or whether the Mixer Machine was fit for purpose.²⁹⁴ Chua XD considered that another mixer machine should be purchased as redundancy in case the Mixer Machine broke down again.²⁹⁵

²⁹⁴ SS-6 (Chua XD), [169].

²⁹⁵ SS-6 (Chua XD), [188].

137 Around the same time, Chua XD gave instructions to Murugan to check on the condition of the Mixer Machine.²⁹⁶ Following his checks, Murugan sent to Chua XD two photographs and a video of the Mixer Machine at 6:10pm.²⁹⁷ Murugan observed that there was an oil stain at the front bottom right corner of the Mixer Machine (*ie*, the location of the fire), reflected in one of the photographs he sent to Chua XD:²⁹⁸



S-116: Photograph of the front (bottom right corner) of the Mixer Machine with the location of the oil stain that Murugan observed on 12 February 2021 outlined in orange colour

²⁹⁶ SS-6 (Chua XD), [170].

²⁹⁷ SS-5 (Murugan), [20]-[21].

²⁹⁸ SS-5 (Murugan), [22]; S-116.

138 Murugan also observed that the Mixer Machine and the oil inside the Mixer Machine were very hot because he could feel the heat and could hear oil boiling sounds from inside the oil jacket, which the video he sent to Chua XD also captured.²⁹⁹

139 Chua XD also observed the oil stain and the boiling sounds from the photograph and video that Murugan had sent to him.³⁰⁰

140 Chua XD then received from Marimuthu three photographs at 6:17pm.³⁰¹ The first two photographs showed that the edges of the insulation which was installed on 6 February 2021 (see [124] above) were burned off.³⁰² The third photograph showed the fire which had taken place earlier, at the front bottom right corner of the Mixer Machine (see [127] above).³⁰³

141 Chua XD alleged that, upon receiving these photographs, he formed the view that the aluminium tape used at the sides of the insulation installed on 6 February 2021 had caught fire and it was not the case that oil had leaked from the oil jacket as he had previously thought (see [132] above).³⁰⁴ Chua XD purported

²⁹⁹ SS-5 (Murugan), [21]; S-163.

³⁰⁰ SS-6 (Chua XD), [173].

³⁰¹ SS-6 (Chua XD), [174].

³⁰² SS-6 (Chua XD), [174]; S-61 and S-62.

³⁰³ SS-6 (Chua XD), [174]; S-63.

³⁰⁴ SS-6 (Chua XD), [174].

that if it were the case that oil leaking from the Mixer Machine had caught fire, then dripping flames would have been (but were purportedly not) visible in the photographs.³⁰⁵ He told Murugan, Moe and Marimuthu that “*The fire stay on the body, no drip flame, so cannot be oil flame*”.³⁰⁶ Chua claimed that photographs and a video which he subsequently received from Murugan of the burn marks on the insulation reinforced his view that it was just the aluminium tape that caught fire and that there had been no oil fire.³⁰⁷

142 Yet, Chua XD still maintained his instructions to weld the Mixer Machine. According to him, this was because he did not know for sure whether there were new cracks on the Mixer Machine.³⁰⁸ Chua XD called Murugan and instructed him to tell Nasim to carry out the welding.³⁰⁹ He also explained to Murugan that an additional plate ought to be added to the bottom of the Mixer Machine.³¹⁰ Chua XD intended the additional bottom plate to catch any leakages, and for any leaked oil caught by the bottom plate to drain out from a hole which was to be cut out of the plate around the Drain Pipe.³¹¹

305 SS-6 (Chua XD), [174].

306 SS-6 (Chua XD), [179].

307 SS-6 (Chua XD), [182]-[183].

308 SS-6 (Chua XD), [185].

309 SS-6 (Chua XD), [185].

310 SS-6 (Chua XD), [185].

311 SS-6 (Chua XD), [185].

143 Murugan sought confirmation of the location where the additional plate ought to be added by taking a photograph of the underside of the Mixer Machine and sending it to Chua XD at 7:13pm.³¹² While taking the photograph, Murugan observed that there was a large oil stain on the underside of the Mixer Machine:³¹³



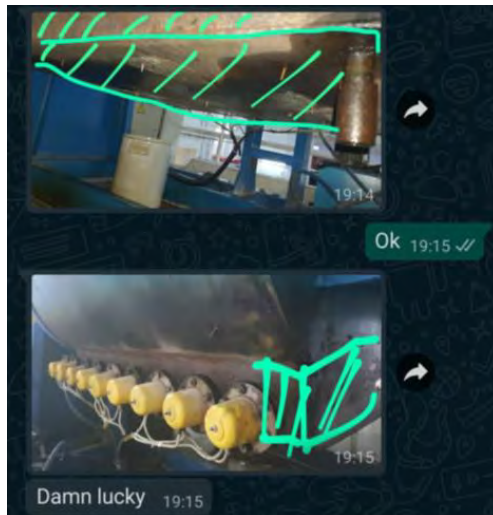
S-117: Photograph of the underside of the Mixer Machine near its front with the location of the oil stain that Murugan observed on 12 February 2021 outlined in orange colour

144 Chua XD followed up at 7:14pm to 7:17pm by sending to Murugan four photographs of the Mixer Machine's exterior with various parts to be welded marked in green and instructing “*All the corner here leaking, so we overlap slightly to cover the leak. Weld dead*”:³¹⁴

³¹² SS-5 (Murugan), [28].

³¹³ SS-5 (Murugan), [28]; S-117.

³¹⁴ SS-6 (Chua XD), [187]; S-20.



S-20: Screenshots from Murugan's mobile phone (taken on 21 June 2021) of his WhatsApp chat messages with Chua XD on 12 February 2021 from 5:19pm to 7:27pm

145 By his instructions, Chua XD meant that corner plates should be added to all four bottom corners of the oil jacket, and that permanent welds were to be done.³¹⁵ Murugan also understood the same.³¹⁶ That evening, Murugan spoke to Nasim and Marimuthu at the workshop, regarding Chua XD's instructions on welding the Mixer Machine. According to Murugan, he showed them the four photographs that Chua XD had sent and the accompanying message (see [144] above), and told them to contact Chua XD for more details when performing the welding.³¹⁷ Murugan assumed that Nasim and Marimuthu understood that Chua XD wanted metal plates to be welded over the underside and at the four bottom corners of the Mixer Machine to cover oil leaks.³¹⁸

146 Chua XD also sent to Moe at 7:26pm three photographs of parts of the Mixer Machine marked in green that he had sent to Murugan earlier (see [144] above) to keep Moe informed on what was going to be done to the Mixer Machine.³¹⁹

³¹⁵ SS-6 (Chua XD), [185]-[187].

³¹⁶ SS-5 (Murugan), [29].

³¹⁷ SS-5 (Murugan), [29].

³¹⁸ SS-5 (Murugan), [31].

³¹⁹ SS-6 (Chua XD), [190].

P. 12 February 2021 – Marimuthu expressed concern for his safety

147 In the aftermath of the fire on 12 February 2021, Marimuthu informed Moe that evening via WhatsApp that he was afraid to work at the workshop and that he was thinking about his young baby in India:³²⁰

Marimuthu: *“this one finish I talk to you”*

Marimuthu: *“better I no work”*

Marimuthu: *“I very sect”*

Marimuthu: *“still I no see baby”*

148 Moe responded by telling Marimuthu to not be scared but Marimuthu insisted that Moe ask Chua XD whether Marimuthu could stop work.³²¹ Moe forwarded Marimuthu’s WhatsApp messages at [147] above to Chua XD and asked Chua XD to speak to Marimuthu about it.

149 Chua XD tried to call Marimuthu that evening but could not get him on the line. Chua XD then sent several text messages to Marimuthu, claiming that the fire was not actually from the Mixer Machine, the Mixer Machine was not dangerous, and that it was not the oil that had caught fire.³²²

³²⁰ SS-7 (Moe), [94].

³²¹ SS-7 (Moe), [94].

³²² SS-6 (Chua XD), [193].

Q. 13 February 2021 – Stars’ workers found cracks on the oil jacket and reported it to Chua XD

150 On 13 February 2021, Nasim began work in relation to the welding of the Mixer Machine at the Tuas Site workshop. Marimuthu was still working at the workshop.

151 According to Nasim, Marimuthu gave him specific instructions on 13 February 2021 to weld all four bottom corners of the oil jacket, and weld additional reinforcement L-shaped plates at the front two bottom corners where oil was leaking.³²³ By this time, all the oil from the oil jacket had already been drained out.³²⁴

152 As a preparatory step, Nasim ground the four bottom corners of the Mixer Machine, along the weld seams, to prepare those areas for welding.³²⁵ He ground away the paint and the manufacturer’s original weldment on those areas.³²⁶

153 After Nasim completed the grinding, he observed that there was a hairline crack on each of the two front bottom corners of the Mixer Machine.³²⁷ Mehedi also

³²³ SS-4 (Nasim), [63]; NE 22 September 2021, pp. 48:10-50:4 (Nasim EIC), pp. 75:25-76:4 (Nasim XX).

³²⁴ SS-4 (Nasim), [62].

³²⁵ SS-4 (Nasim), [64].

³²⁶ SS-4 (Nasim), [64].

³²⁷ SS-4 (Nasim), [65].

observed the cracks and he noticed that the crack on the front bottom left corner was longer than the crack on the front bottom right corner.³²⁸ One crack was about 20mm long and the other was about 50mm long.³²⁹

154 On Nasim’s instructions, Mehedi took a photograph of the longer crack on the front bottom left corner and sent it to Chua XD at 1:49pm, with the accompanying message “*Boss see old welding crack ready*”.³³⁰ Mehedi had observed that the location of the “*old welding crack*” was the same location where Nasim had previously done the welding in October 2020 (see [117] above), and meant by his message “*old welding crack ready*” that Nasim’s previous welding (done in October 2020) had cracked³³¹:

³²⁸ SS-3 (Mehedi), [104].

³²⁹ SS-4 (Nasim), [65].

³³⁰ SS-3 (Mehedi), [105]; S-65.

³³¹ SS-3 (Mehedi), [105]; *cf.* SS-6 (Chua XD), [200] and SS-4 (Nasim), [66].



S-65: Photograph of the “old welding” on the bottom left front corner of the Mixer Machine, sent by Mehedi to Chua XD on 13 February 2021 at 1:49pm via WhatsApp

155 Chua XD replied between 2:49pm-2:50pm, “*Ya la*” and “*Good, we will repair and the machine is good to go again*”.³³² Chua XD also forwarded the

³³² SS-3 (Mehedi), [105]; SS-6 (Chua XD), [201].

photograph of the “old welding crack” to Moe at 2:30pm with the accompanying message “*Old welding crack*”.³³³

156 Apart from the “old welding crack” on the front bottom left corner of the oil jacket, Chua XD was also made aware of the other crack on the oil jacket on 13 February 2021 or 15 February 2021.³³⁴

R. 15-16 February 2021 – Nasim performed welding repairs on the Mixer Machine

157 On 15 February 2021 Nasim returned to the workshop to carry out the welding on the Mixer Machine:³³⁵

(a) Nasim did four layers of welding to each of the four corners of the Mixer Machine, over the areas that he had previously ground on 13 February 2021 (see [152] above).³³⁶

(b) Nasim welded a 90cm x 1m metal plate onto the base of the Mixer Machine, cutting a hole for the Drain Pipe. He attached the metal plate to the underside of the Mixer Machine by welding the two lengths of the metal plate to the corresponding two bottom edges of the front and back sides of

³³³ SS-6 (Chua XD), [201].

³³⁴ SS-6 (Chua XD), [204]; NE 24 September 2021, p. 119:2-7 (Chua XD EIC)

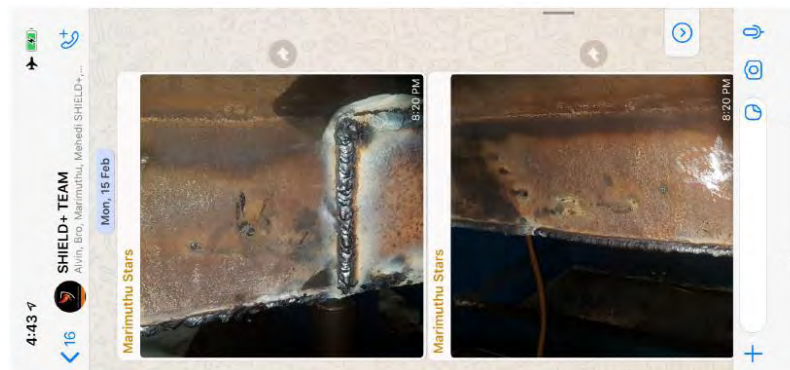
³³⁵ SS-4 (Nasim), [72].

³³⁶ SS-4 (Nasim), [72].

the Mixer Machine. The plate was slightly wider than the Mixer Machine, and there was hence an excess of about 10mm of metal that stuck out from the right and left sides of the Mixer Machine.³³⁷

(c) Nasim then reinforced the front bottom right corner of the Mixer Machine with a metal plate, folded across the corner and welded the metal plate in place, forming an L-shaped plate over the corner.³³⁸

(d) Marimuthu sent two photographs of the Mixer Machine to the Shield+ WhatsApp Chat which showed the welding works done that day (namely, the L-shaped plate at the front bottom right corner of the Mixer Machine and the welding that had been done along the front bottom edge of the Mixer Machine).³³⁹



S-25: Screenshots from Chua XD's mobile phone (taken on 23 June 2021) of the messages from the Shield+ WhatsApp Chat from 15 February 2021, 8.20pm to 17 February 2021, 8.52pm

337 SS-4 (Nasim), [75].

338 SS-4 (Nasim), [76].

339 SS-4 (Nasim), [76]; S-25.

158 Also, on 15 February, Murugan returned to the Tuas Site workshop and repaired the exhaust vent.³⁴⁰

159 The next day, on 16 February 2021, Nasim completed the welding on the Mixer Machine:³⁴¹

(a) Nasim added an additional layer of welding over the two lengths of the base plate which he had welded to the bottom edges of the front and back sides of the Mixer Machine on 15 February 2021 (see [157(b)] above).³⁴²

(b) He reinforced the front bottom left corner of the Mixer Machine by welding an L-shaped plate onto this corner, using the same method as described at [157(c)] above.³⁴³

(c) He then used the hammer to fold the excess width of the base plate over the bottom edges of the right and left sides/faces of the Mixer Machine (see [157(b)] above), and welded the base plate to those faces.³⁴⁴

³⁴⁰ SS-5 (Murugan), [37].

³⁴¹ SS-4 (Nasim), [80].

³⁴² SS-4 (Nasim), [81].

³⁴³ SS-4 (Nasim), [81].

³⁴⁴ SS-4 (Nasim), [82].

160 The welding was completed on 16 February 2021 at about 7pm. According to Nasim, Marimuthu did a visual inspection that evening and had no comments.³⁴⁵

S. 17 February 2021 – Stars’ workers installed new insulation on the Mixer Machine

161 On 17 February 2021, Marimuthu poured oil back into the Mixer Machine’s oil jacket. Chua XD and Nasim claim that Marimuthu found no leaks.³⁴⁶

162 Chua XD visited the workshop on 17 February 2021. This was the first time Chua XD was back at the workshop since the fire on 12 February 2021.³⁴⁷ At the workshop, he checked the welding done by Nasim and did a run through with the Mixer Machine to make a batch of fire clay.³⁴⁸

163 On the same day, new insulation consisting of only fibre glass, without aluminium foil or aluminium tape, was installed on the Mixer Machine.³⁴⁹ Marimuthu sent three photographs that evening at 8:52pm to the Shield+ WhatsApp Chat which showed the new installation.³⁵⁰

³⁴⁵ SS-4 (Nasim), [82].

³⁴⁶ SS-4 (Nasim), [84]; SS-6 (Chua XD), [206].

³⁴⁷ NE 24 September 2021, p. 116:6-8 (Chua XD EIC).

³⁴⁸ SS-6 (Chua XD), [205(e)]; NE 24 September 2021, p. 120:3-18 (Chua XD EIC); SS-4 (Nasim), [85].

³⁴⁹ SS-4 (Nasim), [86].

³⁵⁰ SS-4 (Nasim), [87]; S-25.



S-25: Screenshots from Chua XD's mobile phone (taken on 23 June 2021) of the messages from the Shield+ WhatsApp Chat from 15 February 2021, 8.20pm to 17 February 2021, 8.52pm

T. 24 February 2021 – Small fire on the Mixer Machine in the earlier part of the morning

164 As explained above at [58], a total of eight Stars workers were working at the Tuas Site workshop on 24 February 2021: Anis, Mehedi, Shohel, Marimuthu, Jitu, Yousuf, Rahad and Lizon.³⁵¹

165 At about 8:39am that morning, a small fire broke out at Heater No. 2 on the Mixer Machine:³⁵²



S-73: Photograph of the small fire on the Mixer Machine’s heater on the morning of 24 February 2021, sent by Anis to the Shield+Daily WhatsApp Chat on 24 February 2021 at 8:39am via WhatsApp

³⁵¹ SOAF, [28].

³⁵² SOAF, [29]; [SS-3 (Mehedi), [123]; SS-6 (Chua XD), [214]; S-73.

166 Mehedi was working on the ground floor of the workshop when the fire broke out and he heard Marimuthu call out to him, “*Mehedi, fire*”.³⁵³ Mehedi went up to the Platform and put out the fire using a fire extinguisher.³⁵⁴ Mehedi observed that the isolator for the Mixer Machine had already been turned off.³⁵⁵

167 After the fire was extinguished, Marimuthu asked Mehedi if the Heater No. 2 that had caught fire could be replaced.³⁵⁶ Mehedi told him that there were spare heaters in the store on the second floor of the Tuas Site.³⁵⁷ Mehedi also told Marimuthu to update Chua XD and Moe.³⁵⁸

168 At 8:40am, Marimuthu forwarded the photograph at [165] above to Moe.³⁵⁹ Moe observed that the photograph showed that the flange of one of the Mixer Machine’s heaters was glowing red.³⁶⁰ Immediately after, also at 8:40am, Marimuthu sent Moe three other photographs showing close-ups of Heater No. 2 which showed that the heater was damaged:³⁶¹

³⁵³ SS-3 (Mehedi), [123].

³⁵⁴ SS-3 (Mehedi), [125]; S-168.

³⁵⁵ SS-3 (Mehedi), [125].

³⁵⁶ SS-3 (Mehedi), [128].

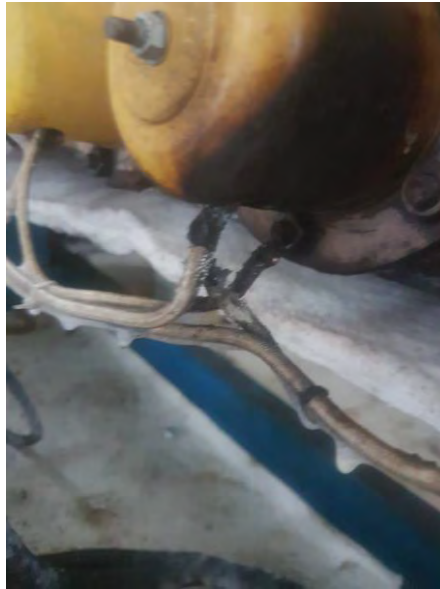
³⁵⁷ SS-3 (Mehedi), [128].

³⁵⁸ SS-3 (Mehedi), [128].

³⁵⁹ SS-7 (Moe), [113].

³⁶⁰ SS-7 (Moe), [113].

³⁶¹ SS-7 (Moe), [113]; S-74; S-75; S-76.



S-74, S-75 and S-76: Photographs of the damaged heater, sent by Marimuthu to Moe on 24 February 2021 at 8:40am via WhatsApp

169 Marimuthu then followed up with two WhatsApp messages: “*heater spoil*”; “*fire the heater*”.³⁶² Moe noted that Heater No. 2 appeared to have been burnt by fire.³⁶³ Moe then had the following exchange with Marimuthu between 8:41am to 8:56pm.³⁶⁴

Moe: “*Die*”

Moe: “*Now machine can ’t on?*”

Marimuthu: “*yes*”

Marimuthu: “*today morning like thet*”

Moe: “*Machine can on ?*”

Marimuthu: “*can but heater I change first*”

Marimuthu: “*you chack boss*”

Moe: “*You message to boss ready ?*”

Marimuthu: “*no*”

Marimuthu: “*I Meg you only*”

Moe: “*You know how to change heater?*”

Marimuthu: “*I tack rdy new one I and sohel change*”

³⁶² SS-7 (Moe), [114].

³⁶³ SS-7 (Moe), [114].

³⁶⁴ SS-7 (Moe), [114]-[119].

170 Marimuthu then sent Moe a photograph of a spare heater that he and Shohel had retrieved from the second floor store.³⁶⁵ Moe understood Marimuthu to be informing him that Marimuthu and Shohel were going to replace the damaged heater.³⁶⁶

171 Marimuthu then asked Moe whether he had informed Chua XD about the matter.³⁶⁷ Moe had not, but he did not respond to Marimuthu's query.³⁶⁸ Marimuthu then messaged Moe again, informing he would be replacing the damaged heater after 10am, when the oil that was in the Mixer Machine's oil jacket cooled down.

³⁶⁵ SS-7 (Moe), [119]; SS-3 (Mehedi), [128]; S-77.

³⁶⁶ SS-7 (Moe), [119].

³⁶⁷ SS-7 (Moe), [120].

³⁶⁸ SS-7 (Moe), [120].

172 At 8:58am, Marimuthu called Moe but Moe did not pick up the call.³⁶⁹ According to Moe, he was driving at that time.³⁷⁰ Marimuthu then sent two close-up photographs of the burnt wiring connections of the damaged heater at 9:04am.³⁷¹



S-78 and S-79: Photographs of the burnt wiring connections of the damaged heater, sent by Marimuthu to Moe on 24 February 2021 at 9:04am via WhatsApp

173 Marimuthu then messaged Chua XD at 9:09am asking whether Chua XD could speak over the phone. Chua XD did not respond.

³⁶⁹ SS-7 (Moe), [121].

³⁷⁰ SS-7 (Moe), [121].

³⁷¹ SS-7 (Moe), [122]; S-78 and S-79.

174 A short while later, at 9:21am, Moe finally updated Chua XD. Moe forwarded to Chua XD all the photographs that Marimuthu had sent to Moe that morning and Marimuthu’s earlier WhatsApp messages “*heater spoil*” and “*fire the heater*”.³⁷² Moe followed up with the following three messages: “*I think we should go tuas*”; “*Heater now muthu changing*”; “*Wire joint may be fire*”.³⁷³ Moe explained that his message “*Heater now muthu changing*” meant that Marimuthu was going to change the heater,³⁷⁴ and that Chua XD would understand that changing the heater meant replacing it with a new heater as that was what the workers, Chua XD and Moe meant whenever they talked about changing a heater.³⁷⁵ Chua XD also admitted that his understanding of Moe’s message “*Heater now muthu changing*” was that the workers were going to take out the damaged heater and put in a new spare heater.³⁷⁶ Chua XD did not reply to these messages.³⁷⁷

175 Chua XD gave Marimuthu a missed call at 9:58am and Marimuthu returned the call at 9:59am.³⁷⁸ According to Chua XD, on this call, Marimuthu updated Chua XD about the matter,³⁷⁹ and Chua XD told Marimuthu to send him photographs of

³⁷² SS-7 (Moe), [123]; SS-6 (Chua XD), [214].

³⁷³ SS-7 (Moe), [123]; SS-6 (Chua XD), [214].

³⁷⁴ SS-7 (Moe), [123].

³⁷⁵ NE 30 September 2021, pp. 79:22-80:12 (Moe EIC).

³⁷⁶ NE 27 September 2021, p. 37:1-14 (Chua XD EIC).

³⁷⁷ SS-7 (Moe), [123].

³⁷⁸ SS-6 (Chua XD), [215].

³⁷⁹ SS-6 (Chua XD), [215].

the damaged heater and that he would get back to Marimuthu.³⁸⁰ Marimuthu sent Chua XD the following two photographs at 10:06am:³⁸¹



S-80 and S-81: Photographs sent by Marimuthu to Chua XD on 24 February 2021 at 10:06am via WhatsApp

176 Marimuthu called Chua XD at 10:07am after sending the above photographs.³⁸² According to Chua XD, on this call, Marimuthu gave Chua XD more information about the fire that morning.³⁸³

³⁸⁰ SS-6 (Chua XD), [215].

³⁸¹ SS-6 (Chua XD), [216]; S-80 and S-81.

³⁸² SS-6 (Chua XD), [216].

³⁸³ SS-6 (Chua XD), [216].

177 At 10:09am, Marimuthu sent Chua XD another photograph of the damaged heater:³⁸⁴



S-82: Photograph sent by Marimuthu to Chua XD on 24 February 2021 at 10:09am via WhatsApp

178 Marimuthu and Chua XD spoke again at 10:10am.³⁸⁵ According to Chua XD, on this call, he had asked Marimuthu whether Marimuthu knew how to change the heater.³⁸⁶ Marimuthu said no.³⁸⁷ Chua XD claimed that although he had used

³⁸⁴ SS-6 (Chua XD), [217]; S-82.

³⁸⁵ SS-6 (Chua XD), [217].

³⁸⁶ SS-6 (Chua XD), [217].

³⁸⁷ SS-6 (Chua XD), [217].

the words “*heater change*”, “*change heater*” when speaking to Marimuthu, his instructions to Marimuthu were only to drain out the oil from the oil jacket, unscrew the flange of the heater and take out the nuts, take out Heater No. 2, and wait for Chua XD to arrive at the Tuas Site workshop.³⁸⁸ Yet, at the same time that Marimuthu was speaking with Chua XD on this call, Marimuthu texted Moe contemporaneously at 10:10am that he was “*now on line*” with Chua XD and “*boss [ie, Chua XD] say heater change*”.³⁸⁹ Moe’s understanding of the message “*boss say heater change*” was that Chua XD had told Marimuthu to replace the damaged heater with a new heater.³⁹⁰

179 Chua XD and Marimuthu spoke for the last time at 10:13am. Chua XD claimed that, in this call, he told Marimuthu to wait until the Mixer Machine cooled down, before the workers drained the oil from the Mixer Machine, and to wait for him to arrive at the Tuas Site. However, there is no corroboration of what transpired during this call, which lasted a good 1 minute and 6 seconds.³⁹¹

180 What is clear is that, despite the fire on the Mixer Machine earlier that morning, Chua XD gave no instructions to cease operations at the workshop altogether that day or any indication that the daily target of fire wrap rolls (which

³⁸⁸ SS-6 (Chua XD), [217]; NE 27 September 2021, pp. 42:11-43:14 (Chua Re-ex).

³⁸⁹ SS-7 (Moe), [125].

³⁹⁰ NE 30 September 2021, p. 81:10-19 (Moe EIC).

³⁹¹ SS-6 (Chua XD), [217].

required two batches of fire clay to be produced in the day³⁹²) no longer needed to be met.

181 We submit that the above evidence regarding the communications between Chua XD, Marimuthu and Moe clearly shows that Chua XD had told Marimuthu to replace the damaged Heater No. 2 with a new heater with the expectation, which Marimuthu understood, that the workers should continue with that day's production of fire clay using the Mixer Machine once the damaged heater was dealt with.

182 In any event, Mehedi saw Marimuthu and Shohel doing something near the Mixer Machine's heaters on the Platform.³⁹³ Lizon also saw Shohel and Marimuthu doing something near the Mixer Machine's heaters.³⁹⁴

183 About half an hour before the explosion, Mehedi heard the Mixer Machine's motor running, indicating that it was in the process of mixing and a few seconds later it stopped.³⁹⁵ Jitu heard the sound of the Mixer Machine operating at about 11am.³⁹⁶ Lizon heard the sound of the Mixer Machine in operation just before the explosion.³⁹⁷ Yousuf heard the Mixer Machine running before the explosion.³⁹⁸

³⁹² NE 21 September 2021, p. 99:10-22 (Mehedi Re-ex).

³⁹³ SS-3 (Mehedi), [129].

³⁹⁴ SS-12 (Lizon), [62].

³⁹⁵ SS-3 (Mehedi), [130].

³⁹⁶ SS-9 (Jitu), [75].

³⁹⁷ SS-12 (Lizon), [63].

³⁹⁸ NE 28 September 2021, p. 116:11-16 (Yousuf EIC).

184 At 11:03am, Moe called Marimuthu and they spoke for 36 seconds.³⁹⁹ It is disputed by Moe that Marimuthu had discussed the damaged Heater No. 2 with Moe during this call.⁴⁰⁰

185 Yet, at 11:10am, Moe sent Marimuthu a message asking, “*How Muthu? Heater ok?*”, which by Moe’s own admission, meant that he wanted an update from Marimuthu on the damaged heater.⁴⁰¹

186 In response, Marimuthu sent Moe a photograph at 11:13am, which Moe confirmed looked almost identical to a photograph taken by Marimuthu on 24 February 2021 at 11:13am and extracted from Marimuthu’s phone by the Cyber Crime Response Team, Jurong Division, Singapore Police Force (“**SPF**”).⁴⁰²

³⁹⁹ S-33, S/N 26.

⁴⁰⁰ NE 30 September 2021, pp. 95:12-96:8 (Moe EIC).

⁴⁰¹ SS-7 (Moe), [126].

⁴⁰² SS-7 (Moe), [127]; S-83.



S-83: Photograph taken by Marimuthu on 24 February 2021 at 11:13am showing that the wiring of the damaged Heater No. 2 had been taped together with green tape, extracted from Marimuthu's mobile phone

187 Moe knew, on seeing the photograph sent by Marimuthu at 11:13am, that the damaged Heater No. 2 was still in the oil jacket and had not been changed, and

that the wiring of the damaged heater had been taped together with green tape.⁴⁰³ Moe purportedly thought at the time he was sent the photograph that Marimuthu was going to check the connectivity of the damaged heater with the wiring taped together.⁴⁰⁴

188 Tellingly, Moe expressed no surprise on seeing the photograph of the taped damaged heater bolted into the oil jacket. Instead, Moe replied to Marimuthu at 11:32 am saying “*Ok let me know ASAP*”.⁴⁰⁵ Far from instructing Marimuthu and the workers not to try using the damaged heater in any way, we submit that Moe had clearly sanctioned the workers’ attempts to check if the damaged heater could still be used.

189 Moe deleted the photograph received from Marimuthu at 11:13am, as well as his message to Marimuthu at 11:32am, from his and Marimuthu’s mobile phones after the Accident (see [444]-[445] below).⁴⁰⁶

190 The damaged Heater No. 2 with the green taped-wiring was found still in the oil jacket, after the Accident.⁴⁰⁷

⁴⁰³ SS-7 (Moe), [127].

⁴⁰⁴ SS-7 (Moe), [127].

⁴⁰⁵ SS-7 (Moe), [128].

⁴⁰⁶ SS-7 (Moe), [127].

⁴⁰⁷ S-289 (MOM’s Investigation Report), [2.3.8].

U. 24 February 2021 – Accident at the Tuas Site workshop

191 CCTV footage from Alif-E⁴⁰⁸ showed that the Accident occurred at 11:22 am.⁴⁰⁹ The CCTV footage indicated that a large explosion first occurred at around 11:22am, followed in the next few minutes by flash fires.⁴¹⁰

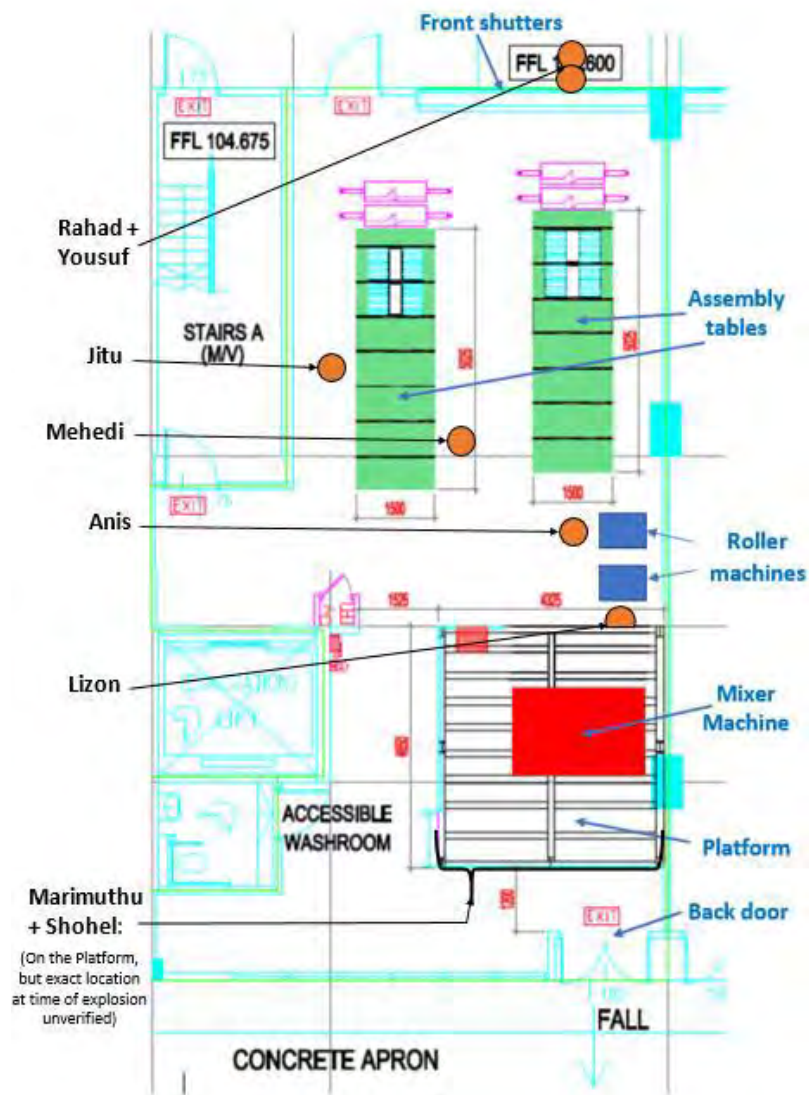
192 When the explosion occurred, the Stars workers were at various locations at in Tuas Site workshop, as plotted in the diagram below:⁴¹¹

⁴⁰⁸ S-175–S-182.

⁴⁰⁹ S-289 (MOM’s Investigation Report), [3.1.7].

⁴¹⁰ S-283 (Dr Salim’s Report), p. 12, Table 1; S-288 (SCDF’s Investigation Report), pp. 12-15, Screenshots 24, 31 and 33.

⁴¹¹ SS-1 (State Counsel’s Opening Statement), [83].



193 They felt the large explosion. In particular:

- (a) Yousuf felt intense heat and an impact across his back, that caused him to fall about two metres forward to the ground;⁴¹²

⁴¹² SS-10 (Yousuf), [68].

(b) Rahad felt a huge push, that caused him to fly about two metres backwards to the ground;⁴¹³

(c) Mehedi felt a gust of hot air pushing him, and causing him to fall;⁴¹⁴

(d) Lizon felt as if something hot had fallen on the back of his neck;⁴¹⁵
and

(e) Jitu felt hot oil splashing on him and heard hot oil splashing on the wall above him.⁴¹⁶ He saw the whole workshop was on fire and filled with black smoke.⁴¹⁷

194 Following the explosion, the Stars workers ran out of the workshop to the open field at the back of the industrial estate.⁴¹⁸ Other workers from neighbouring units at the industrial estate came out and sprayed water on the injured Stars workers using a hose.⁴¹⁹

⁴¹³ SS-11 (Rahad), [68].

⁴¹⁴ SS-3 (Mehedi), [132].

⁴¹⁵ SS-12 (Lizon), [63], [66].

⁴¹⁶ SS-9 (Jitu), [76].

⁴¹⁷ SS-9 (Jitu), [76].

⁴¹⁸ SS-3 (Mehedi), [131]; SS-11 (Rahad), [72].

⁴¹⁹ SS-3 (Mehedi), [132]; SS-11 (Rahad), [72].

195 Two workers from P3, Miah and Zhao, who were working in the area outside and opposite of the Tuas Site workshop also felt the large explosion:

(a) Miah heard an explosion and felt a lot of wind. He also saw a big fire inside the Tuas Site workshop and flames coming out of the workshop;⁴²⁰ and

(b) Zhao first saw a fire measuring about two metres across inside the Tuas Site workshop where he knew the Mixer Machine was located, and then heard a loud explosion. He also saw flames coming out of the workshop.⁴²¹

196 At about 11:23am, the SCDF Operations Centre received multiple calls from members of public and the Police Operations Command Centre informing of the explosion and fire.⁴²² The first SCDF crew arrived at the Tuas Site at about 11:30am.⁴²³ The fire was eventually extinguished by the SCDF at about 11:46am.⁴²⁴

⁴²⁰ SS-13 (Miah), [6].

⁴²¹ SS-14 (Zhao), [7]; NE 29 September 2021, p. 112:8-19 (Zhao, questions by IC); p. 117:11-16 (Zhao Re-ex).

⁴²² SOAF, [33].

⁴²³ SOAF, [33].

⁴²⁴ SOAF, [33].

197 The SCDF observed, when it arrived at the Tuas Site workshop on 24 February 2021, that the isolator for the Mixer Machine was in an “ON” state⁴²⁵ and that the control panel switches for the Mixer Machine’s heaters were in an “ON” state.⁴²⁶ During the SCDF’s further investigation on 25 February 2021, the SCDF observed that the Moulded Case Circuit Breaker (MCCB) of the Mixer Machine’s control panel was also in an “ON” state.⁴²⁷ These observations from the SCDF indicate that at the time of the explosion, electrical power was supplied to the Mixer Machine and its heaters were turned on.⁴²⁸

198 The SCDF was, however, unable to determine if the Emergency Stop button on the Mixer Machine’s control panel was in an un-depressed state in the immediate aftermath of the explosion.⁴²⁹ If, for example, the Emergency Stop button had been found in a depressed state, it would have indicated that electrical power to the Mixer Machine had been cut off and that the Mixer Machine was not in operation at the time of the explosion.⁴³⁰ In this regard, the Licensed Electrical Worker (“LEW”) engaged by Matcor had subsequently found that the Emergency Stop button was in

⁴²⁵ NE 7 October 2021, p. 68:1-8 (Maj Huang EIC).

⁴²⁶ NE 7 October 2021, p. 68:9-21 (Maj Huang EIC).

⁴²⁷ NE 7 October 2021, pp. 66:22-67:21 (Maj Huang EIC).

⁴²⁸ S-288 (SCDF’s Investigation Report), [8(i)].

⁴²⁹ NE 7 October 2021, pp. 67:22-68:8 (Maj Huang EIC).

⁴³⁰ NE 4 October 2021, pp. 27:16-28:1 (Matcor EIC).

a depressed state during the LEW's examination⁴³¹ but this is inconclusive as the LEW's examination was only conducted in March 2021.⁴³²

V. Aftermath of the Accident

199 As a result of the Accident, there was property damage to the Tuas Site and two other surrounding units (leased by Alif-E and P3 respectively) and there were several casualties.

1. Property damage from the Accident

200 The Tuas Site workshop sustained extensive property damage as a result of the Accident. The rear wall of the workshop had collapsed causing debris to be scattered around the back lane of the workshop.⁴³³ The front shutters of the workshop were damaged.⁴³⁴ A portion of the workshop's side wall (close to the ceiling) adjoining Alif-E's unit had also collapsed⁴³⁵ causing debris to be scattered inside Alif-E's unit. Many of the equipment inside the Tuas Site workshop, including the Mixer Machine, were also damaged.⁴³⁶ As regards the Mixer

⁴³¹ S-279 (Matcor Report), p. 177.

⁴³² NE 4 October 2021, pp. 30:12-31:18 (Matcor EIC); NE 7 October 2021, p. 135:2-23 (Ms Lim Re-ex).

⁴³³ S-87.

⁴³⁴ S-100.

⁴³⁵ S-88.

⁴³⁶ SOAF, [35].

Machine, significant damage was observed at the lower portion of the back of the Mixer Machine's oil jacket where it had ruptured open along its welding seams.⁴³⁷

201 In relation to the exterior of the Tuas Site, three louvre panels from the second and third floors of the building had fallen off from the building.⁴³⁸ A fourth louvre panel was observed to be hanging from the third floor of the building⁴³⁹ and was subsequently brought down by Stars.⁴⁴⁰

202 The Accident also caused four rear window panels of P3's Unit 38A to be blasted out of their frames.⁴⁴¹

2. *Casualties from the Accident*

203 A total of ten persons suffered injuries from the Accident. Three of them succumbed to their injuries. Details of the ten casualties are provided below.

(a) Deceased persons

204 Anis, Marimuthu and Shohel were pronounced dead at the Singapore General Hospital ("SGH") on 24 February 2021 at 9:53pm, 24 February 2021 at

⁴³⁷ S-279 (Matcor Report), pp. 37-38.

⁴³⁸ SOAF, [36].

⁴³⁹ S-91.

⁴⁴⁰ SOAF, [36].

⁴⁴¹ S-136.

10:46pm, and 25 February 2021 at 3:06am respectively. The findings from their autopsies are as stated in their respective Autopsy Reports.⁴⁴² These include that each had approximately 90% of their total body surface area affected by burns, and that their cause of death was certified as “*SEVERE BURNS*”.

(b) Injured persons

205 Seven other persons suffered injuries from the Accident and were conveyed to the hospital to receive treatment. Five of them were the other Stars workers working at the Tuas Site workshop on the day of the Accident (*ie*, Lizon, Jitu, Mehedi, Yousuf and Rahad). They suffered serious burn injuries and were treated at SGH. The remaining two injured persons were the two P3 workers working across the Tuas Site workshop (*ie*, Miah and Zhao). They were treated at Ng Teng Fong General Hospital.

206 Their respective injuries are set out in their respective Medical Reports, and are summarised in the table below:⁴⁴³

⁴⁴² S-213, S-215 and S-214.

⁴⁴³ SOAF, [43].

S/N	Injured Person	Summary of Injuries Sustained	Exhibit Reference
1	Lizon	<p>(1) 37% Total Body Surface Area (TBSA) burns over the face, neck, scalp, bilateral upper limbs, back, abdomen, flank, left knee and foot.</p> <p>(2) Bilateral ocular thermal injury.</p> <p>(3) Left otomycosis.</p>	S-220
2	Jitu	<p>(1) 54% TBSA over the face, neck, anterior chest, back and bilateral upper and lower limbs.</p> <p>(2) Bilateral ocular thermal injury with high intraocular pressure.</p> <p>(3) Bilateral cicatrical ectropion.</p>	S-223

S/N	Injured Person	Summary of Injuries Sustained	Exhibit Reference
3	Mehedi	<p>(1) 58% TBSA burns over the face, neck, scalp, anterior chest, bilateral upper limbs, back, buttocks and left lower limb.</p> <p>(2) Bilateral ocular thermal injury with high intraocular pressure.</p> <p>(3) Bilateral otitis externa.</p> <p>(4) Cytomegalovirus and herpes simplex virus viraemia.</p>	S-219
4	Yousuf	<p>(1) 35% TBSA burns over the face, neck, scalp, bilateral upper limbs, chest/abdomen and right foot.</p> <p>(2) Bilateral ocular thermal injury.</p> <p>(3) Bilateral otitis externa.</p>	S-221

S/N	Injured Person	Summary of Injuries Sustained	Exhibit Reference
5	Rahad	<p>(1) 48.5% TBSA burns over the face, neck, scalp, bilateral upper limbs, chest/abdomen, back and left foot.</p> <p>(2) Bilateral ocular thermal injury with high intraocular pressure.</p> <p>(3) Bilateral otitis externa.</p> <p>(4) Sepsis with polymicrobial bacteraemia.</p>	S-222
6	Zhao	Approximately 8% TBSA Superficial partial thickness burns over the left forearm, right forearm, head/face and neck.	S-225
7	Azam	Minor head injury from barotrauma.	S-224

IV. TOR A – CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

207 Having set out the background facts and key events leading to the Accident on 24 February 2021, we now turn to discuss the causes of the Accident. We do so in two parts – we first look at the technical causes of the Accident, before going on to explore the underlying root causes giving rise to the series of events precipitating the Accident.

A. The proximate technical causes of the Accident

208 In respect of the technical causes of the Accident, we submit that there are three issues to determine:

- (a) What was the technical cause(s) of the rupture of the oil jacket's back bottom weld seams;
- (b) What was the technical causes(s) of the explosion; and
- (c) What was the technical cause(s) of the subsequent flash fires.

209 As set out at [15] above, evidence was led from Matcor, Dr Salim, Prof Chew, SCDF, Ms Lim and Hawkins for this area.

210 Parties agree that the primary explosion itself was chemical in nature, which was caused by the ignition of thermic oil aerosols on a heated surface.⁴⁴⁴ However, parties differ on the mechanics of how such a chemical explosion occurred – whether it occurred following a physical rupture of the oil jacket due to internal overpressure; or whether it occurred inside the oil jacket, and caused the physical rupture of the oil jacket.

211 While Matcor, Dr Salim and SCDF consider that the oil jacket had first physically ruptured due to overpressures within the oil jacket caused by the overheating of thermic oil, Hawkins' position is that the rupture of the oil jacket was caused by a chemical explosion within the oil jacket.

212 Parties also diverge on the cause of the subsequent flash fires: while Dr Salim opines that the flash fires were caused by ignition of potato starch which became airborne from the initial explosion, Dr Rose opines that the flash fires were caused by the ignition of smoke plumes which contained hydrocarbons from the incomplete combustion of the thermic oil.

⁴⁴⁴ S-283 (Dr Salim's Report), p. 58:8-14; ST-1 (Hawkins Report), [6.1.12].

213 The following areas will be addressed in turn:

(a) The cause of the initial explosion, which parties agree was chemical in nature and caused by the ignition of thermic oil aerosols on a heated surface;

(b) The cause of the rupture of the oil jacket, which we submit was physically caused by the pressures within the oil jacket from the overheating of the thermic oil; and

(c) The cause of the subsequent flash fires, which we submit were most likely caused by the ignition of the potato starch powder found at the Tuas Site.

1. The explosion was chemical in nature caused by the ignition of thermic oil aerosols on a heated surface

214 There is no dispute on the mechanism of the initial explosion itself – it was caused by the ignition of thermic oil aerosols and was chemical in nature.

215 Dr Salim opined that the pressurised release of thermic oil from the rupture of the oil jacket likely “*atomised the [thermic oil] to form a liquid aerosol that was then probably ignited by a hot surface. The ignited aerosol cloud resulted in the primary deflagration with estimated overpressures in the range of 2.1 kPa to 58*

kPa".⁴⁴⁵ Dr Salim compared the damage found at the Tuas Site and its surrounding units to the reference overpressures from the "Guidelines for evaluating the characteristics of vapor cloud explosions, flash fires, and BLEVES" issued by the Center for Chemical Process Safety⁴⁴⁶ to obtain the peak overpressures generated during the primary deflagration. Thereafter, Dr Salim excluded the possibility of a purely physical explosion as the peak overpressures calculated for a physical explosion, which were between 0.42 and 5.3 kPa,⁴⁴⁷ were too low to account for the extent of damage observed in the aftermath of the Accident.

216 In contrast, industrially used liquids can be atomised by pressures only a few bars above atmospheric pressure and ignited by energy sources as low as 100 mJ.⁴⁴⁸ Heat transfer fluids ("**HTFs**") with flash points ranging from 149°C to 260°C have been shown to ignite at room temperature,⁴⁴⁹ and there have been incidents involving the ignition of HTFs and other heavy hydrocarbons in the past.⁴⁵⁰ The range of peak overpressures possible with thermic oil ignition was also consistent with the damage observed.⁴⁵¹

⁴⁴⁵ S-283 (Dr Salim's Report), p. 8:3-7.

⁴⁴⁶ S-283 (Dr Salim's Report), p. 34, footnote 8.

⁴⁴⁷ S-283 (Dr Salim's Report), p. 36, Table 6.

⁴⁴⁸ S-283 (Dr Salim's Report), p. 37:6-8.

⁴⁴⁹ S-283 (Dr Salim's Report), p. 37:13-14.

⁴⁵⁰ S-283 (Dr Salim's Report), p. 37:27 – p. 38:10.

⁴⁵¹ S-283 (Dr Salim's Report), pp. 39 – 43.

217 Dr Salim initially posited that the heated flange of Heater No. 2 could have been a possible ignition source if the Mixer Machine was re-started in the morning of 24 February 2021.⁴⁵² However, he clarified on the stand that there were a lot of possible ignition sources, such as the circuits in the control panel of the Mixer Machine or its motors.⁴⁵³ It was also possible for the heater coils inside the Mixer Machine to have been the ignition source after the oil jacket had split open, exposing the heater coils to the atomised thermic oil aerosols.⁴⁵⁴

218 This is consistent with SCDF's position that the thermic oil was the first fuel for the initial fire,⁴⁵⁵ and that while the exact ignition source could not be conclusively determined,⁴⁵⁶ it could be one or more of the following three sources, namely:⁴⁵⁷

- (a) The hot surfaces of the overheated heating coils;
- (b) The autoignition of the thermic oil which required no spark or flame to be initiated; and/or
- (c) The arcing sparks at the terminal lugs of Heater No. 2.

⁴⁵² S-283 (Dr Salim's Report), pp. 61:15-19.

⁴⁵³ NE 5 October 2021, p. 135:6-18 (Dr Salim, questions from IC).

⁴⁵⁴ NE 6 October 2021, p. 209:7-17 (Dr Salim, questions from IC).

⁴⁵⁵ S-288 (SCDF's Investigation Report), p. 18, [8(n)].

⁴⁵⁶ S-288 (SCDF's Investigation Report), p. 19, [9(d)].

⁴⁵⁷ S-288 (SCDF's Investigation Report), p. 18, [8(n)].

219 Maj Huang explained that the only competent fuel in the vicinity of the Mixer Machine was the thermic oil,⁴⁵⁸ and the plumes of black smoke captured by CCTV were indicative that thermic oil was likely involved for the fire.⁴⁵⁹ He elaborated that each ignition source was possible once oxygen was not the limiting factor,⁴⁶⁰ but the most probable ignition source were the heating coils after the rupture of the oil jacket, due to their higher temperatures.⁴⁶¹

220 Hawkins also thought that the explosion was caused by the ignition of aerosolised thermic oil by exposed heating coils. Dr Rose indicated that the ignition of an oil mist would generate sufficient pressures to account for the damage that was observed at the Tuas Site and its surrounding units,⁴⁶² though he had not calculated whether the ignition of oil mist *within* the oil jacket as posited by him would have caused such sufficient pressure.⁴⁶³ Dr Rose explained that the oil mist formed is very stable as the droplets are very small, and has a similar ignition energy and lower flammable limit than (oil) vapour, but can be ignited with a lower heat input.⁴⁶⁴

458 NE 7 October 2021, p. 89:20-23 (Maj Huang EIC).

459 NE 7 October 2021, pp. 89:23-90:2 (Maj Huang EIC).

460 NE 7 October 2021, pp. 91-95 (Maj Huang EIC).

461 NE 7 October 2021, p. 97:1-15 (Maj Huang EIC).

462 ST-1 (Hawkins Report), [6.1.12].

463 NE 6 October 2021, pp. 137:19-138:23 (Dr Rose XX).

464 ST-1 (Hawkins Report), [6.1.12].

221 While Dr Rose's primary position was that the ignition of the oil mist by the heating elements inside the oil jacket caused the rupture of the oil jacket,⁴⁶⁵ he acknowledged during the Inquiry hearing that oil mist released into the environment after rupture of the oil jacket could have come into contact with the (then) exposed heating elements and ignited.⁴⁶⁶

222 The immediate cause of the primary deflagration, which resulted in the damage observed in the Tuas Site and its surrounding units, as well as the injuries sustained by the Stars workers, Miah and Zhao, is therefore not in doubt. The explosion itself was caused by the chemical ignition of aerosolised thermic oil on any hot surface within the Tuas Site, which could have included the hot heating coils once they were exposed to the atmosphere.

2. *The rupture of the oil jacket was caused by high pressures created from the overheating of thermic oil*

223 The main divergence in opinion on the proximate causes of the Accident on 24 February 2021 relates to how the oil jacket had ruptured. Dr Salim and SCDF have taken the position that the oil jacket had ruptured first, before the subsequent ignition of the thermic oil which caused the primary deflagration.⁴⁶⁷ Matcor and Dr

⁴⁶⁵ ST-1 (Hawkins Report), [6.1.12].

⁴⁶⁶ NE 6 October 2021, pp. 201:8-203:16; p. 205:8-16 (Dr Rose, questions from IC).

⁴⁶⁷ S-283 (Dr Salim's Report), p. 8:3-7; NE 7 October 2021 pp. 73:14-74:11 (Maj Huang EIC).

Salim assessed that the rupture was due to the high pressures created by the overheating of thermic oil over time, which were retained in the oil jacket from the closing of all the vents of the Mixer Machine.⁴⁶⁸ Matcor also opined that the situation was compounded by the poor welding repairs done on the Mixer Machine, which weakened the strength of the welds on the Mixer Machine.⁴⁶⁹

224 Hawkins, in contrast, has posited that the rupture of the oil jacket was caused by a chemical explosion within the oil jacket itself, and that overheating of the heating elements occurred only on 24 February 2021.⁴⁷⁰ Hawkins has also asserted that the weld repairs done by Nasim had no effect on the explosion.⁴⁷¹

225 The position taken by Matcor, Dr Salim and SCDF should be preferred over Hawkins' position, for the following reasons:

- (a) A physical rupture of the oil jacket is consistent with what was observed during operation of the Mixer Machine;
- (b) A physical rupture of the oil jacket is consistent with the investigations conducted by Matcor and its implications;

⁴⁶⁸ S-279 (Matcor Report), pp. 24:29-26:15; S-283 (Dr Salim's Report), p. 8:2-4.

⁴⁶⁹ S-279 (Matcor Report), p. 27:4-10.

⁴⁷⁰ ST-1 (Hawkins Report), [6.1.12]-[6.1.14].

⁴⁷¹ ST-1 (Hawkins Report), [7.7].

(c) A physical rupture of the oil jacket is consistent with the calculations on the temperature and pressure inside the oil jacket, and with observations on the strength of the welds;

(d) A physical rupture of the oil jacket is consistent with there being insufficient oxygen for a chemical explosion within the oil jacket;

(e) Hawkins' theory that a chemical explosion within the oil jacket caused its rupture rests on speculation that the heating elements were exposed within the oil jacket on 24 February 2021 and further, on the flawed assumption that that was the only occasion they were so exposed; and

(f) A physical rupture of the oil jacket was capable of taking place regardless whether the Mixer Machine was actually in operation at the point of the Accident.

226 We now go on to address each of these reasons in turn.

(a) A physical rupture of the oil jacket is consistent with what was observed during operation of the Mixer Machine

227 There were multiple observable signs between August 2020 and February 2021 that the Mixer Machine was experiencing significant stresses caused by the high temperatures and pressures within the oil jacket. Several of these observable signs are examined in greater detail below at [350]-[392] to demonstrate Stars'

failure to respond appropriately to red flags and near-misses. In this Section, however, we highlight these observable signs for the particular purpose of demonstrating that, when viewed cumulatively, they support the conclusion that there was a physical rupture of the Mixer Machine due to overpressure. This runs counter to Hawkins' assertion that the Mixer Machine was operating at relatively low temperatures, and at close to atmospheric pressure throughout its lifespan.⁴⁷²

(i) DETERIORATED GASKETS

228 First, as stated above at [95]-[96], the gaskets of the Mixer Machine were worn out by 28 August 2020 and had to be changed. When Matcor examined the replaced gaskets, these were hard and brittle, and Mr Shandro commented that this was likely due to high temperatures and accelerated aging of the gaskets during the whole period of operation.⁴⁷³ When shown a photograph of the deteriorated gaskets taken on 28 August 2020,⁴⁷⁴ Dr Rose acknowledged that the temperature of the oil could have been much higher than 250°C for the gaskets to have deteriorated in that fashion, but sought to qualify his answer by saying that it was not the clearest photograph, and that there was unburnt paint on the flanges as well.⁴⁷⁵

⁴⁷² ST-1 (Hawkins Report), [2.4.13].

⁴⁷³ NE 4 October 2021, pp. 87:10-89:20 (Matcor XX).

⁴⁷⁴ S-113.

⁴⁷⁵ NE 6 October 2021, pp. 102:16-103:12 (Dr Rose XX).

(ii) OIL DRAINED FROM THE OIL JACKET WAS BLACK

229 Second, the colour of the used thermic oil drained from the Mixer Machine on each occasion was close to black, and there were sediments found in the drained oil (see [94] and [111] above). This was a clear indication that the oil was being subjected to high temperatures beyond its operating range. Chua XD acknowledged that this showed that the thermic oil was subject to temperatures higher than 300°C.⁴⁷⁶ Mr Shandro stated that the thermic oil was subject to temperatures above its boiling point, such that there was burning of the thermic oil, and the sediments reveal that there was burning of the thermic oil, such that coke, or concentrated carbons, were created.⁴⁷⁷ Dr Salim stated that the oil turning black in colour was indicative of a chemical reaction happening within the oil due to high temperature.⁴⁷⁸ The pressures created by operating the oil jacket at such temperatures as to result in the oil turning almost black would have been significant, as was the case after 8 August 2020, when the vents of the oil jacket were plugged.

(iii) WHITE SMOKE FROM THE OIL JACKET

230 Third, from 28 August 2020 onwards, white smoke was observed from the area where the Mixer Machine's heaters were located (see [98] and [122] above).

⁴⁷⁶ NE 27 September 2021, p. 179:4-7 (Chua XD, questions from IC).

⁴⁷⁷ NE 4 October 2021, pp. 52:10-54:11 (Matcor EIC).

⁴⁷⁸ NE 5 October 2021, pp. 60:11-61:2 (Dr Salim EIC).

In relation to the video sent by Moe to Chua XD on 8 January 2021 showing white smoke from the oil jacket (see [121] above),⁴⁷⁹ Dr Salim commented that the white smoke could be aerosols formed either by condensation of oil vapours, or ejection of the oil directly via very small holes in the oil jacket. He explained that pressures of a few bars were required to atomise industrially used liquids.⁴⁸⁰ Dr Rose accepted that cracks and leaks were indicative of pressures greater than atmospheric within the oil jacket, though he chose not to comment on the precise pressures attained.⁴⁸¹

(iv) BOILING SOUNDS FROM THE OIL JACKET

231 Fourth, there were boiling sounds from the oil jacket that were heard by those at the workshop, including Chua XD.⁴⁸² Other Stars workers have also reported hearing such boiling sounds (see [99] and [138] above). When Dr Salim was asked to comment, he stated that the sounds could be due to boiling, or alternatively due to the decomposition of the thermic oil,⁴⁸³ both of which would have been caused by high temperatures and resulted in pressure increase within the oil jacket.

⁴⁷⁹ S-159.

⁴⁸⁰ NE 5 October 2021, pp. 58:9-60:4 (Dr Salim EIC).

⁴⁸¹ NE 6 October 2021, pp. 145:19-148:11 (Dr Rose XX).

⁴⁸² SS-6 (Chua XD), [173]; NE 28 September 2021, p. 22:2-18 (Jitu EIC); see also [99] and [138] above.

⁴⁸³ NE 5 October 2021, p. 63:3-20 (Dr Salim EIC).

(v) CRACKS ON THE OIL JACKET

232 Fifth, there were cracks seen on the welds of the Mixer Machine on 28 September 2020 (see [100] above), 12 October 2020 (see [113] above) and 13 February 2020 following the fire on 12 February 2021 (see [153] above). The fire on 12 February 2021 was due to the ignition of oil vapours from one of the cracks found on the oil jacket, as opined by Dr Salim⁴⁸⁴ and Maj Huang.⁴⁸⁵ The cracks necessitated welding repairs made by Nasim, which did not look even in appearance.⁴⁸⁶ Even the welds from October 2020 had cracked by February 2021, as testified by Mehedi,⁴⁸⁷ and acknowledged by Nasim as possible.⁴⁸⁸ When shown the video taken by Mehedi of the hairline crack and leak on 12 October 2020,⁴⁸⁹ Dr Salim and Dr Rose agreed that the pressure inside the oil jacket must have been higher than atmospheric pressure to result in the thermic oil “weeping” from the Mixer Machine,⁴⁹⁰ though Chua XD purported to disagree that the video showed the thermic oil spraying or spurting out of the oil jacket⁴⁹¹ (as we submit the

484 NE 5 October 2021, pp. 67:7-68:14 (Dr Salim EIC).

485 NE 6 October 2021, pp. 99:10-102:6 (Dr Rose XX).

486 S-279 (Matcor Report), p. 8:26.

487 SS-3 (Mehedi), [105].

488 NE 22 September 2021, p. 55:1-13 (Nasim EIC).

489 S-158.

490 NE 5 October 2021, p. 66:1-9 (Dr Salim EIC); NE 6 October 2021, pp. 145:15-146:3 (Dr Rose XX).

491 NE 24 September 2021, p. 37:1-21 (Chua XD EIC); NE 27 September 2021, p. 98:15-20 (Chua XD XX).

objective videographic evidence clearly shows). In relation to the photograph of the fire on 12 February 2021 sent by Marimuthu to Chua XD,⁴⁹² Maj Huang also commented that the outward direction of the fire indicated that it was caused by pressure inside the oil jacket.⁴⁹³

233 When asked what the presence of cracks show about the pressures reached in the oil jacket, Mr Shandro succinctly commented that as pressure increases and the welded joints are working in tension, there would be some voids created by the tensile stress, linking together to form cracks.⁴⁹⁴ Mr Shandro also opined that after the repairs in February 2021, these cracks may have been welded closed, but this resulted in the pressures always being high⁴⁹⁵ from the boiling/cracking/evaporation of the thermic oil, which was sufficient to cause the rupture of the oil jacket on its own.⁴⁹⁶

(vi) DISCOLOURATION OF THE MIXER MACHINE

234 Finally, there was paint discolouration at the lower parts of the Mixer Machine, which according to Dr Rose, would reflect that the air within the oil jacket

⁴⁹² S-63.

⁴⁹³ NE 7 October 2021, pp. 100:10-103:10 (Maj Huang EIC).

⁴⁹⁴ NE 4 October 2021, p. 109:19-24 (Matcor Re-ex).

⁴⁹⁵ NE 4 October 2021, pp. 50:18-51:15 (Matcor EIC).

⁴⁹⁶ NE 4 October 2021, p. 77:16-20 (Matcor EIC).

was at least 333°C.⁴⁹⁷ He also agreed that the location where the paint discolouration took place would reflect where temperatures of 333°C and above were reached within the Mixer Machine.⁴⁹⁸

235 When shown the photograph Imam took of the oil jacket on 28 September 2020 (see [100] above),⁴⁹⁹ Dr Rose agreed that there was already discolouration of the paint by then, and agreed that the inside of the oil jacket must have reached such temperatures by then.⁵⁰⁰ This is an indication that the temperatures reached within the oil jacket exceeded the temperature at which there would have been significant boiling/evaporation/cracking of the thermic oil, and this was already the case by 28 September 2020, almost half a year before the explosion.

236 As seen above, there were multiple signs that the Mixer Machine was operating at high temperatures and pressures throughout its lifespan, namely: (a) rapid wearing out of gaskets; (b) colour of used thermic oil and presence of sediments; (c) presence of white smoke emanating from the oil jacket; (d) boiling sounds during operation; (e) cracks on weld joints of the Mixer Machine; and (f) paint discolouration on the Mixer Machine. While each of these signs could possibly be explained away via other means, cumulatively they point to the

⁴⁹⁷ NE 6 October 2021, p. 93:9-20 (Dr Rose XX).

⁴⁹⁸ NE 6 October 2021, p. 94:11-22 (Dr Rose XX).

⁴⁹⁹ S-52.

⁵⁰⁰ NE 6 October 2021, pp. 94:23-95:22 (Dr Rose XX).

conclusion that the Mixer Machine was subject to temperature and pressure stresses far beyond its operating capacity. The physical rupture of the oil jacket on 24 February 2021 is consistent with this conclusion.

(b) A physical rupture of the oil jacket is consistent with the investigations conducted by Matcor and its implications

237 The Matcor Report yields findings in three additional areas which lend credence to the position that there was a physical rupture of the oil jacket arising from high temperatures and build-up of pressures over time – namely, (a) oil jacket levels over time, (b) the dimples found within the welds, and (c) grain growth being detected on the used heating elements. Each of these will be addressed in turn.

(i) OIL LEVELS

238 First, based on the purchase history of thermic oil,⁵⁰¹ and the dimensions of the Mixer Machine as measured, Matcor had created a 3D Model of the Mixer Machine, to calculate the oil fill levels for different amounts of thermic oil, as shown at Appendix G and Table 4⁵⁰² of the Matcor Report. We elaborate on the various oil fill levels of the Mixer Machine throughout its operating life at [311]-[321] below.

⁵⁰¹ See Section III above.

⁵⁰² S-279 (Matcor Report), p. 23.

239 For now, we would simply observe that the oil fill level at any point in time could not have been more than 160L, and this would have been insufficient for good heat conduction. Even if we were to assume that there was no loss of thermic oil (*ie*, there were 160L of thermic oil in the oil jacket) at the time of the explosion, the thermic oil still would not have been in contact with the W-shaped base of the mixing chamber of the Mixer Machine.⁵⁰³ As explained by Mr Shandro, when the level of thermic oil was low, heat transfer would be through the air that is between the oil level and the bottom of the W-shaped mixing chamber, and air is a very bad conductor.⁵⁰⁴ This would require the equipment to heat up a lot, and the oil would have been overheated, before the temperatures required in the mixing chamber were reached via convection taking place.⁵⁰⁵

240 Consequently, the thermic oil within the oil jacket would therefore have been overheated throughout the entire period of operation of the Mixer Machine, resulting in the pressures within the sealed oil jacket being correspondingly high as well.

241 Hawkins was aware of the purchase history of the thermic oil, as this was reflected in the Hawkins Report at [2.4.2]⁵⁰⁶ and [3.5].⁵⁰⁷ Hawkins was also given

⁵⁰³ NE 4 October 2021, p. 73:16-24 (Matcor EIC).

⁵⁰⁴ NE 4 October 2021, p. 73:1-5 (Matcor EIC).

⁵⁰⁵ NE 4 October 2021, p. 73:5-11, p. 75:3-10 (Matcor EIC).

⁵⁰⁶ ST-1 (Hawkins Report), p. 11.

⁵⁰⁷ ST-1 (Hawkins Report), p. 20.

the 3D modelling for some of the oil levels on 6 July 2020 via email.⁵⁰⁸ However, Hawkins failed to account for the actual oil levels (which it could have objectively derived) in its opinion – it asserted that the oil level within the oil jacket would nominally be about 300mm above the base of the mixing chamber and that the heaters would be fully submerged within normal conditions.⁵⁰⁹ When asked to explain this, Dr Rose accepted that the oil levels were as modelled by Matcor, and could only say that the precise difference in temperatures between the surface of the thermic oil and the mixing chamber depends on the clearance levels in between.⁵¹⁰ It is evident that the part of Hawkins’ opinion which asserts that the operating temperatures within the oil jacket were lower than the boiling point of water within the mixing chamber⁵¹¹ must be rejected.

(ii) DIMPLES ON WELDS

242 Matcor had conducted macroscopic, metallographic/microscopic and fractographic examination on the welds of the Mixer Machine. The fractographic examination revealed that the Mixer Machine was subject to high pressures for an extended period. This is consistent with the position that the Mixer Machine had ruptured physically, and is inconsistent with Hawkins’ view that it was an

⁵⁰⁸ S-289 (MOM’s Investigation Report), pp. 115, 132-137.

⁵⁰⁹ ST-1 (Hawkins Report), [5.4].

⁵¹⁰ NE 6 October 2020, p. 96:13-24 (Dr Rose XX).

⁵¹¹ ST-1 (Hawkins Report), [6.1.4] and [6.1.10].

instantaneous chemical explosion which ruptured the oil jacket of the Mixer Machine.

243 The fractographic examination of the welds showed that there were both equiaxed and elongated dimples on the fracture surfaces,⁵¹² which reveal how the Mixer Machine had ruptured. As stated in the Matcor Report, the high pressure had resulted in the deformation of the wall, void nucleation and cracks, as evidenced by the equiaxed dimples which were perpendicular to the fracture surface. The final rupture was evidenced by the elongated dimples which were adjacent to the external side.⁵¹³ Mr Shandro further explained that these dimples show that at the beginning there was just tensile stress applied on the part that was under pressure, which created some voids and reduced the “section” of welds, such that with time and overpressure the explosion took place.⁵¹⁴

244 This runs directly counter to Hawkins’ position that it was an instantaneous chemical explosion which caused the rupture of the Mixer Machine, as the equiaxed dimples would not have been observed if that was so. The photographs showing the presence of equiaxed and elongated dimples had been provided to Hawkins on 1 June 2021, even before Hawkins asked to inspect the Mixer Machine and conduct

⁵¹² S-279 (Matcor Report), pp. 14:26-15:22.

⁵¹³ S-279 (Matcor Report), pp. 14:26-15:22.

⁵¹⁴ NE 4 October 2021, pp. 118:15-119:6 (Matcor, questions from IC).

tests on it.⁵¹⁵ Dr Rose acknowledged after extensive questioning that this was out of his area of expertise, and he was prepared to accept Mr Shandro's opinion, as Mr Shandro is a materials scientist.⁵¹⁶

245 The detailed examinations by Matcor on the welds therefore show that the Mixer Machine was subject to high pressures over time resulting in the Mixer Machine eventually giving way physically, which was not challenged by Hawkins.

(iii) GRAIN GROWTH ON THE USED HEATING ELEMENTS

246 The presence of grain growth on the used heating elements, as well as another heating element retrieved from the Tuas Site, when compared to new heating elements, also supports the position that the oil jacket was operating under very high temperatures during operation.

247 As explained by Mr Ng, grain growth takes place whenever low carbon steels are heated to temperatures beyond 700°C, with time, so that austenite grains are observed.⁵¹⁷ Mr Shandro added that it is not possible for grain growth to just take place in the course of one explosion as was observed on 24 February 2021, as it is a long process which happens when low carbon steels are heated for a long

⁵¹⁵ S-289 (MOM's Investigation Report), pp. 48, 99-103.

⁵¹⁶ NE 6 October 2021, pp. 150:13-151:9 (Dr Rose XX).

⁵¹⁷ NE 4 October 2021, pp. 61:9-62:20 (Matcor EIC).

time. Grain growth is therefore an indication of the high temperatures at which the heaters were operating.⁵¹⁸

248 Matcor had examined Heaters No. 2, 5, and 8 from the Mixer Machine, another heater which was found on site with blisters which was handed to MOM by Chua XD on 31 May 2021,⁵¹⁹ and a new/unused spare heater. Heater No. 2 was chosen as there was an earlier fire involving it on 24 February 2021, whilst Heaters No. 5 and 8 were chosen to reflect one heater from each group of three heaters controlled by a different switch, and to give a good sampling size of 33 percent of the number of heaters in operation.⁵²⁰

249 Matcor found that the average grain size in the new/unused spare heater was smaller, at ASTM numbers 9 to 10.⁵²¹ In contrast, Heaters No. 2, 5 and 8 had shown average grain sizes which were larger, between ASTM numbers 0 and 5.⁵²² The difference in grain sizes showed that there was grain growth taking place, where Heaters No. 2, 5, and 8 had been exposed to temperatures above 700°C, such that the grain sizes in the used heaters were larger than those in the new/unused spare heater.⁵²³ Also, when a heater was bolted into the oil jacket, some of its metal tubes

⁵¹⁸ NE 4 October 2021, pp. 63:11-64:8 (Matcor EIC).

⁵¹⁹ SS-6 (Chua XD), [230].

⁵²⁰ NE 4 October 2021, pp. 60:3-61:8 (Matcor EIC).

⁵²¹ S-279 (Matcor Report), p. 19:13-14.

⁵²² S-279 (Matcor Report), p. 19:23-41.

⁵²³ NE 4 October 2021, pp. 64:9-65:9 (Matcor EIC).

would be in a higher position (from the base of the oil jacket) relative to other metal tubes of that heater. As the metal tubes higher up in Heaters No. 2 and 8 generally showed larger grain sizes than those which were lower, it meant that the metal tubes higher up in each heater likely sustained higher heating temperatures than those located lower down.⁵²⁴

250 Similarly, the average grain size for the heater with blisters was found to be between ASTM numbers 3 and 4, which shows that it had been used and had experienced grain growth.⁵²⁵

251 Matcor had then correlated the grain sizes found on the used heaters with a table exhibited at page 25 of the Matcor Report. This exercise showed that the heaters had been exposed to temperatures from 830°C to 1095°C previously.⁵²⁶ Such temperatures were far above the recommended operating temperatures of the Mixer Machine, which were stated as between 70°C and 160°C in its User Guide. They were also far in excess of the design temperature of 200°C.⁵²⁷ This definitively shows that the heaters, and by connection the thermic oil, were exposed to temperatures far beyond its operating capacity, and this would have resulted in the boiling/evaporation/cracking of the thermic oil within the oil jacket.

⁵²⁴ S-279 (Matcor Report), p. 19:42-46.

⁵²⁵ S-279 (Matcor Report), p. 20:4-8.

⁵²⁶ S-279 (Matcor Report), p. 25.

⁵²⁷ S-271, p. 4, Section Eight.

252 Matcor's photographs showing grain growth were shared with Hawkins through Stars' counsel on 6 July 2021.⁵²⁸ Dr Rose stated that he did not dispute these findings but asserted that heaters were meant to get hot,⁵²⁹ and made no effort to compare the design temperature of the oil jacket with the temperatures reflected by the grain growth observed on the used heaters in the Hawkins Report. Dr Rose acknowledged that he is not a materials scientist or metallurgist, and Mr Graham Cooper, who was one, may not have had the opportunity to review the photographs showing grain growth in detail.⁵³⁰ Hawkins had evidently not taken grain growth in the heaters into account in their opinion. The assertion that the Mixer Machine was operating within its designed operating temperature before 24 February 2021⁵³¹ should therefore be rejected.

(c) A physical rupture of the oil jacket is consistent with the calculations on the temperature and pressure inside the oil jacket, and with observations on the strength of the welds

253 To cause the physical rupture of the oil jacket from overpressures within the oil jacket, the pressures reached within the oil jacket would need to significantly exceed 2 bar, which is the maximum working pressure of the Mixer Machine as

⁵²⁸ S-289 (MOM's Investigation Report), pp. 115-131.

⁵²⁹ NE 6 October 2021, pp. 98:21-100:20 (Dr Rose XX).

⁵³⁰ NE 6 October 2021, pp. 140:21-144:17 (Dr Rose XX).

⁵³¹ ST-1 (Hawkins Report), [2.4.14].

stated in its User Guide.⁵³² This would require the operating temperatures within the oil jacket to exceed 320-350°C, which are the temperatures beyond which significant decomposition of the thermic oil takes place as tested by A*Star.⁵³³ The calculations on the temperatures and pressures which could be attained within the oil jacket during operation show that the oil jacket sustained pressures far beyond what it was designed to work with. This was exacerbated by the poor quality of the repair welding done by Nasim, which reduced the pressures that the oil jacket could withstand.

254 Finite Element Analysis (“**FEA**”) was performed by Dr Salim, to estimate the temperatures reached within the oil jacket when the fill volume of the thermic oil was 230L. Based on the assumption of moderate convection and 45kW heat source, where the mixing chamber of the Mixer Machine was filled with liquid which was not agitated, the maximum temperature reached by the thermic oil within the oil jacket ranged between 427°C and 714°C.⁵³⁴ This would already have been sufficient for the thermic oil to undergo decomposition.

255 As explained further in Dr Salim’s Report, the conditions when the actual 176L of water was heated in the mixing chamber of the Mixer Machine fell within the FEA modelling range of 5 to 500 W/m²K, such that the temperatures of 427°C

⁵³² S-271, p. 4, Section Eight.

⁵³³ S-283 (Dr Salim’s Report), pp. 29-32.

⁵³⁴ S-283 (Dr Salim’s Report), p. 23:14-18.

to 714°C could be taken as a reasonable base-case representation. The presence of insulation on the external surfaces of the Mixer Machine, and the actual levels of thermic oil used being far below 230L at all times, would have resulted in the temperatures of the thermic oil being higher than the base-case, which could result in phase changes and potential decomposition of the thermic oil.⁵³⁵

256 The consequences of operating the Mixer Machine while the temperatures of the thermic oil were above 427°C to 714°C are severe. As shown in Figure 11 of Dr Salim's Report, when the temperature was held at 350°C during one of the test runs, the pressure increased from 2 bar to 6 bar, which is already one to three times the maximum working pressure of the Mixer Machine. When the experimental temperature was extended to 450°C, which is at the lower range of the base-case representations without accounting for the presence of insulation and low fill levels of thermic oil, the pressure exponentially increased to 103 bar, which resulted in the termination of the experiment for safety reasons.⁵³⁶

257 It is evident that the Mixer Machine was not designed to be operated at pressures above 100 bar, which would be *50 times* its maximum working pressure.

258 This was compounded by the welds being weakened by the poor quality of the repair welds by Nasim. The macroscopic analysis by Matcor showed that the

⁵³⁵ S-283 (Dr Salim's Report), pp. 25:14-26:4.

⁵³⁶ S-283 (Dr Salim's Report), pp. 30 and 31.

repair welds had weld caps that were uneven in appearance and without the paint coating.⁵³⁷ Mr Shandro stated that the repair welds were not of good quality, and that they were not uniform to the naked eye.⁵³⁸ He further explained that the speed of movement of the electrode,⁵³⁹ weld procedures and cleanliness of surface,⁵⁴⁰ quality of weld metal and filler metal⁵⁴¹ were factors which could affect the quality of welding. He opined that the poor quality of repairs in this case was due to there being no preparation, with the repair welds being done over the existing welds without cleaning.⁵⁴² This is consistent with what Nasim admitted during the Inquiry hearing, in that he had merely removed the paint before conducting welding without removing the weld metal,⁵⁴³ and he was aware that proper preparation of the area to be welded by cleaning and grinding was key to ensuring smooth and even welding.⁵⁴⁴

259 The microscopic/metallographic examination confirmed that the repair welds were of poor quality, with cracks, porosities and discontinuities at multiple locations.⁵⁴⁵ This reduced the integrity and strength of the oil jacket, as the presence

⁵³⁷ S-279 (Matcor Report), p. 8:22-27.

⁵³⁸ NE 4 October 2021, p. 34:19-20 (Matcor EIC).

⁵³⁹ NE 4 October 2021, p. 34:23-24 (Matcor EIC).

⁵⁴⁰ NE 4 October 2021, p. 36:16-17 (Matcor EIC).

⁵⁴¹ NE 4 October 2021, p. 36:17-18 (Matcor EIC).

⁵⁴² NE 4 October 2021, p. 37:13-22 (Matcor EIC).

⁵⁴³ NE 22 September 2021, p. 61:11-17 (Nasim EIC).

⁵⁴⁴ SS-4 (Nasim), [6].

⁵⁴⁵ S-279 (Matcor Report), pp. 17:1-18:33.

of weld porosities and poor weld roots act as stress raisers and promoted cracking.⁵⁴⁶ Mr Shandro also explained that the resistance of the weld overall would be affected by having the repair welds over the original welding, as the structure of the weld would have been modified and coarsened with gross grains, such that this affects the hardness and resistance of the welding material.⁵⁴⁷ Nasim agreed that his welds were not of good quality, after being shown the microscopic examination photographs within the Matcor Report.⁵⁴⁸ While there were porosities found in the original welding as well, there was no opinion that the original welds were poor in quality⁵⁴⁹ by either Matcor or Hawkins in their reports. There is also a distinct difference in the number of cracks, discontinuities and voids between the original and the repair welds as shown in the Matcor Report.

260 In contrast, while the Hawkins Report stated that the repair welds were of poor quality visually,⁵⁵⁰ Hawkins asserted that the welding repairs did not have an effect, as the oil jacket had failed along the original welded joints,⁵⁵¹ without accounting for the effect of the poor repairs on the strength of the welds as a whole. It is evident that Hawkins' focus was on whether the oil jacket ruptured at a different

⁵⁴⁶ S-279 (Matcor Report), p. 27:4-10.

⁵⁴⁷ NE 4 October 2021, p. 40:5-16 (Matcor EIC).

⁵⁴⁸ NE 22 September 2021, p. 68:2-6 (Nasim EIC).

⁵⁴⁹ NE 4 October 2021, p. 84:2-8 (Matcor XX).

⁵⁵⁰ ST-1 (Hawkins Report), [5.2].

⁵⁵¹ ST-1 (Hawkins Report), [6.4.1].

location due to the repairs, than on whether the strength of the welds was affected by the repairs done.

261 The quantitative effect of having weak welds is significant. Mr Shandro had calculated that based on the resistance of the area, and the strength of the material of the Mixer Machine which was low carbon steel, the pressure limit with poor quality welds would only be half of when there were good weldings.⁵⁵² This would have reduced the maximum working pressure of the Mixer Machine to 1 bar, which is atmospheric pressure, and the possible pressures reached being *more than 100 times* that of the pressures the Mixer Machine could sustain.

262 In such operating environments, it is not surprising that the eventual outcome was the physical rupture of the oil jacket along its welds, which were comparatively weaker than the rest of the Mixer Machine.

263 When confronted with the pressures which could be reached at the temperatures which the thermic oil were subject to within the oil jacket, Dr Rose made the bare assertion that he did not know the details of the tests so that he could not replicate them if he wanted to, and claimed that there were gaps in the available information such as the condition of the thermic oil tested.⁵⁵³ After it was pointed out to Dr Rose that the test runs were conducted on fresh thermic oil, and that the

⁵⁵² NE 4 October 2021, pp. 45:23-46:16 (Matcor XX).

⁵⁵³ NE 6 October 2021, pp. 106:8-107:24 (Dr Rose EIC).

SDT tests were conducted on both fresh thermic oil and thermic oil samples retrieved from the Tuas Site, he qualified his acknowledgement of the pressure trends observed during the test runs by stating that this was obtained using the test conditions in the test equipment.⁵⁵⁴ He eventually acknowledged that at the temperature of 350°C, which would be below the base-case representation of the temperatures within the oil jacket, that decomposition of the thermic oil would have taken place, such that there would be pressure build-up.⁵⁵⁵

(d) *A physical rupture of the oil jacket is consistent with there being insufficient oxygen for a chemical explosion within the oil jacket*

264 For a fire to take place, all three elements of the fire triangle need to be satisfied – namely, there must be sufficient fuel, oxygen, and heat.⁵⁵⁶ However, there was insufficient oxygen within the sealed oil jacket, such that it was impossible for a chemical explosion to have taken place within it.

265 As shown in Dr Salim’s Addendum quantitatively, assuming that there was *no* thermic oil in the oil jacket, the volume of air inside the oil jacket would have been around 300L, which yields the amount of oxygen available for combustion as around 0.0026 mol.⁵⁵⁷ If the TNT-equivalent approach was used in estimating the

⁵⁵⁴ NE 6 October 2021, p. 108:13-24 (Dr Rose XX).

⁵⁵⁵ NE 6 October 2021, pp. 108:25-109:23 (Dr Rose XX).

⁵⁵⁶ NE 5 October 2021, p. 127:6-11 (Dr Salim Re-ex).

⁵⁵⁷ S-283A (Dr Salim’s Addendum), p. 2:5-15.

amount of oxygen required for alkanes with between 5 and 40 carbon atoms, beyond which the hydrocarbon would likely be in a solid state at room temperature, the minimum amount of oxygen required, which would be for the incomplete combustion of C40 hydrocarbons to carbon, would be 0.0119 mol, almost five times the amount of oxygen present in the completely empty oil jacket.⁵⁵⁸ Using the oil mist concentration method to estimate the minimum amount of oxygen required for combustion yields a similar result of 0.0109 mol for the incomplete combustion of C40 hydrocarbons to carbon, which is also more than four times the amount of oxygen present in the completely empty oil jacket.⁵⁵⁹

266 This was confirmed by Maj Huang qualitatively as well. He explained that under normal conditions, before the rupture of the oil jacket, everything was sealed and intact, and oxygen would have been a limiting factor for combustion.⁵⁶⁰ He further explained that oxygen is always critical in supporting combustion, such that combustion would not have taken place if any of the elements was a limiting factor or was not in the correct proportion.⁵⁶¹ Once the oil jacket has ruptured, oxygen would then be introduced to the environment, facilitating combustion.⁵⁶²

⁵⁵⁸ S-283A (Dr Salim's Addendum), p. 5.

⁵⁵⁹ S-283A (Dr Salim's Addendum), p. 8.

⁵⁶⁰ NE 7 October 2021, pp. 73:23-74:11; pp. 91:16-92:7 (Maj Huang EIC).

⁵⁶¹ NE 7 October 2021, pp. 94:23-95:1 (Maj Huang EIC).

⁵⁶² NE 7 October 2021, p. 95:2-6 (Maj Huang EIC).

267 When asked to comment on the calculations, Dr Rose made the sweeping statement that the calculations done were “*gross oversimplifications*”.⁵⁶³ He claimed that only sufficient burning was required to rupture the vessel, and the rest of the overpressures generated could have taken place outside after the oil jacket ruptured.⁵⁶⁴ He also claimed, disingenuously, that there was “*no difference*” whether the chemical explosion occurred inside and/or outside the oil jacket as the bottom line was that the oil level was low.⁵⁶⁵ He acknowledged that he had not done any modelling or calculations in coming to this position, instead relying on an example of a fire involving a gearbox in a warship which purportedly had a very small enclosure about the size of the oil jacket⁵⁶⁶ to assert that combustion was possible within the oil jacket. He eventually capitulated, saying that he had not thought that the amount of oxygen present in the oil jacket would be a contentious issue.⁵⁶⁷ This excuse is difficult to comprehend when the presence of sufficient oxygen is one of the elements required for combustion to occur.

268 In contrast, a physical rupture of the oil jacket does not require *any* oxygen to be present: the evaporation/boiling/thermal decomposition of the thermic oil does not require oxygen to be present, merely requiring heat and the presence of thermic

⁵⁶³ NE 6 October 2021, p. 65:17-18 (Dr Rose EIC).

⁵⁶⁴ NE 6 October 2021, p. 66:10-19 (Dr Rose EIC).

⁵⁶⁵ NE 6 October 2021, p. 66:20-24 (Dr Rose EIC).

⁵⁶⁶ NE 6 October 2021, p. 138:1-11 (Dr Rose EIC).

⁵⁶⁷ NE 6 October 2021, p. 139:1-9 (Dr Rose XX).

oil, both of which were present in abundance within the oil jacket when the Mixer Machine was in operation. The low level of oxygen within the oil jacket is therefore a factor which strengthens the position that it was a physical rupture of the oil jacket caused by the build-up of pressure, and militates against the position that it was a chemical explosion taking place within the oil jacket.

(e) Hawkins' theory that a chemical explosion within the oil jacket caused its rupture rests on speculation that the heating elements were exposed within the oil jacket on 24 February 2021 and further, on the flawed assumption that that was the only occasion they were so exposed

269 An essential plank of the Hawkins opinion (that a chemical explosion inside the oil jacket caused its rupture) is that the heating elements were exposed within the oil jacket on 24 February 2021, and further, that that was the only occasion on which the heaters were so exposed.

270 As stated in the Hawkins Report, a fire inside the oil jacket would occur only if the oil level were low and the heating elements exposed (even partly) to the air.⁵⁶⁸ As confirmed by Dr Rose during the Inquiry hearing, his theory would

⁵⁶⁸ ST-1 (Hawkins Report), [6.1.11]-[6.1.12].

require one or more of the heaters to be glowing red hot, which requires oil levels to be too low such that the heaters were exposed.⁵⁶⁹

271 Going by Hawkins' theory, however, it would mean that there was the possibility of a chemical explosion within the Mixer Machine *whenever* the heaters were exposed such that they could glow red hot. Seeking to exclude this possibility, it was asserted in the Hawkins Report that the oil level within the oil jacket would “*nominally be about 300 mm above the base of the mixing chamber*” and that “*the heaters would be fully submerged under normal conditions*”.⁵⁷⁰

272 It was also postulated that there was an oil leak at Heater No. 2 on 24 February 2021, caused by the fire earlier that morning, or that oil had leaked out from the flange of Heater No. 1 due to the removal of two nuts from it prior to the Accident, such that the oil levels dropped sufficiently to partially expose the heating elements as an ignition source within the oil jacket, only right before the Accident on 24 February 2021.

273 Hawkins' theory is however not in line with the oil levels within the Mixer Machine over time (see [316]-[318] below).

⁵⁶⁹ NE 6 October 2021, p. 35:6-12 (Dr Rose EIC).

⁵⁷⁰ ST-1 (Hawkins Report), [5.4].

274 When asked for an explanation on why the Mixer Machine did not rupture between 16 June 2020 to 8 August 2020 when only 40L of oil were used, Dr Rose claimed that the oil level was so low that it did not get “super-heated”,⁵⁷¹ and that the situation on 24 February 2021 was different as part of the heaters were exposed while part of the heaters were submerged,⁵⁷² such that Stars “*just got lucky*” between 16 June 2020 to 8 August 2020.⁵⁷³ However, this explanation would not pass muster for the period after 8 August 2020, when 3 buckets of fresh thermic oil were added to the 1½ buckets of thermic oil drained from the Mixer Machine, making 90L of thermic oil within the oil jacket, and sometime after, when at least 10L from the fourth bucket of thermic oil was added (see [88]-[89] above). During this period, based on professional modelling done by Matcor, part of the heater coils would still have been exposed, and there would have been sufficient oil to be in contact with the heating elements directly as well.⁵⁷⁴ Such a situation would have been identical to what was speculated by Hawkins to have caused the chemical explosion within the oil jacket on 24 February 2021. There is no satisfactory explanation for why the explosion did not take place any earlier on Hawkins’ theory.

275 Second, the loss of significant amounts of thermic oil on 24 February 2021 itself is highly speculative, and not in line with what was observed at the Tuas Site.

⁵⁷¹ NE 6 October 2021, p. 154:8-13 (Dr Rose XX).

⁵⁷² NE 6 October 2021, p. 154:14-18 (Dr Rose XX).

⁵⁷³ NE 6 October 2021, p. 155:2-13 (Dr Rose XX).

⁵⁷⁴ S-279 (Matcor Report), pp. 160-161.

As explained by Mr Shandro, the lustrous rings around the two rightmost bolts on Heater No. 1 suggest that the two nuts were only removed *after* the Accident on 24 February 2021. This is confirmed by the photograph at S-84, which was taken of Heater No. 1 on 24 February 2021, which showed that the two bolts in question were still there when the MOM first responders attended at the Tuas Site.⁵⁷⁵ Upon questioning, Dr Rose finally acknowledged that it did not look that possible that such significant amounts of thermic oil would have leaked out from Heater No. 2 after the first fire on 24 February 2021.⁵⁷⁶ Dr Rose was left to suggest that the amount of oil used was less than 120L to begin with.⁵⁷⁷

276 As such, the evidence does not support Hawkins' position that there were significant leakages and the heating coils were only exposed on 24 February 2021, resulting in the chemical explosion within the oil jacket. This further bolsters the position that it is a physical rupture of the oil jacket, with the weakening of the welds over time caused by the increased pressures within the oil jacket which was operated as a closed system.

⁵⁷⁵ NE 4 October 2021, pp. 74:11-76:24 (Matcor EIC).

⁵⁷⁶ NE 6 October 2021, p. 134:4-8 (Dr Rose XX).

⁵⁷⁷ NE 6 October 2021, p. 133:11-22 (Dr Rose XX).

(f) *A physical rupture of the oil jacket was capable of taking place regardless whether the Mixer Machine was actually in operation at the point of the Accident*

277 Finally, the physical rupture of the oil jacket could have taken place on 24 February 2021, even if the Mixer Machine was not in operation at the point of the Accident. This is unlike a chemical explosion within the oil jacket, which Dr Rose indicated was premised on the Mixer Machine being turned on again after the first instance when it was turned off at 8:40am,⁵⁷⁸ such that the heaters were red hot during operation.

278 No such difficulty arises with the physical rupture of the oil jacket due to pressure build-up. Such physical rupture of the oil jacket could take place as long as the thermic oil was heated to temperatures beyond 320°C for some time, such that there is decomposition of the thermic oil resulting in a great increase in the pressures within the oil jacket.⁵⁷⁹ As explained by Dr Salim, the decomposition of the thermic oil used in the oil jacket was a net exothermic reaction.⁵⁸⁰ Once the temperature for onset of decomposition of the oil was exceeded, a certain amount of heat would be released, and that heat can then be used by the reaction itself to

⁵⁷⁸ NE 6 October 2021, p. 198:9-14 (Dr Rose, questions from IC).

⁵⁷⁹ NE 5 October 2021, pp. 45:13-46:25 (Dr Salim EIC).

⁵⁸⁰ NE 5 October 2021, pp. 54:24-56:6 (Dr Salim EIC); see also Appendix D of S-273.

break more bonds and crack more or decompose more molecules,⁵⁸¹ so the oil jacket may not cool down and reduce in pressure that quickly after the heaters were turned off. Additionally, even after the oil jacket cools down, the pressure may not return to 1 bar because the lighter fragments created by the decomposition of the thermic oil could remain in the gaseous phase.⁵⁸² As such, the oil jacket may continue to experience increased pressures which would serve to exert stress on the welds of the Mixer Machine.

279 As explained by Mr Shandro, the heating coils would have taken some time to cool down on 24 February 2021 as well, and there was insulation installed on the Mixer Machine, such that the pressures attained during the operation of the Mixer Machine before 8:40am could be maintained at almost the same level.⁵⁸³

280 As stated above at [278], Dr Salim had explained that the decomposition of the thermic oil used in the oil jacket was a net exothermic reaction.⁵⁸⁴ The temperatures reached in the oil jacket during the operation of the oil jacket between 8:15am and 8:40am on 24 February 2021 would have been between 400-500°C, which was sufficient for decomposition of thermic oil to take place.⁵⁸⁵ Even if the Mixer Machine was turned off between 8:40am and 11:22am on 24 February 2021

⁵⁸¹ NE 5 October 2021, p. 51:5-18.

⁵⁸² NE 5 October 2021, pp. 50:6-51:2 (Dr Salim EIC).

⁵⁸³ NE 4 October 2021, pp. 133:2-134:17 (Matcor Re-ex).

⁵⁸⁴ NE 5 October 2021, pp. 54:24-56:6 (Dr Salim EIC); see also Appendix D of S-273.

⁵⁸⁵ NE 5 October 2021, pp. 70:8-73:23 (Dr Salim EIC).

when the explosion took place, pressures could continue to increase in the intervening period, as long as temperatures were above 320°C, and the decomposition of thermic oil created more heat within the closed system of the oil jacket, aided by the presence of insulation on the oil jacket.⁵⁸⁶ Such an increase in pressure could be significant: as explained by Dr Salim, maintaining the temperature at 350°C during the laboratory tests conducted resulted in the pressures increasing from 2 to 6 bar,⁵⁸⁷ which would be three times the working pressure of the Mixer Machine.⁵⁸⁸

281 This is important, especially when there is some doubt on whether the heating elements in the Mixer Machine were in operation when the Accident took place. As rightly observed by the IC, and as we have summarised the evidence at [183] above, Mehedi stated that he had heard the Mixer Machine’s motor stop for a while after the first fire on 24 February 2021, which shows that the Mixer Machine was no longer in the mixing mode.⁵⁸⁹ In contrast, Lizon stated that he thought the Mixer Machine was in operation when the explosion occurred, Jitu noticed that the Mixer Machine was turned on again around 11 am,⁵⁹⁰ Yousuf said that he heard the

⁵⁸⁶ NE 5 October 2021, p. 74:2-24 (Dr Salim EIC).

⁵⁸⁷ NE 5 October 2021, pp. 75:7-76:18 (Dr Salim EIC).

⁵⁸⁸ S-271, p. 4, Section Eight.

⁵⁸⁹ SS-3 (Mehedi), [130].

⁵⁹⁰ SS-9 (Jitu), [75].

Mixer Machine running before the explosion, whereas Rahad was not even aware of any issue concerning the Mixer Machine in the morning of 24 February 2021.⁵⁹¹

282 Hawkins' theory requires the heating elements to have been turned on at the time of the incident. However, if the Mixer Machine was not in operation at the time of the incident, the ignition for a chemical explosion within the oil jacket could not have taken place, but a physical rupture of the oil jacket due to built-up pressure within could still have happened. This is another reason to find that the physical rupture of the oil jacket due to built-up pressure within was the most likely mechanism for the weld failures.

(g) *Summary of discussion on the physical rupture of the Mixer Machine*

283 To summarise the discussion above, what was plainly observable during operation of the Mixer Machine, the investigations by Matcor, and the calculations on the temperatures and pressures in the oil jacket, and observations on weld strength support the position that the rupture of the Mixer Machine was physical in nature, caused by the build-up of pressure in the Mixer Machine due to the overheating and decomposition of thermic oil within the oil jacket of the Mixer Machine. The low levels of oxygen in the oil jacket, the speculative nature of Hawkins' theory which requires the heating elements to become exposed *only* on

⁵⁹¹ SS-11 (Rahad), [66].

24 February 2021 after the first fire in the morning, and the need to account for the possibility that the Mixer Machine was not in operation when the explosion took place, militate against the far-fetched possibility that the rupture of the Mixer Machine was caused by a chemical explosion within its oil jacket. The evidence of Matcor, Dr Salim and SCDF should therefore be accepted.

3. *The subsequent flash fires were most likely caused by the ignition of the potato starch suspended by the initial deflagration*

284 As observed in the CCTV footage retrieved from Alif-E, there were three flashes observed some time after the initial deflagration, as summarised in Dr Salim’s Report,⁵⁹² and referred to in SCDF’s review of the footage:⁵⁹³

Timestamp		Event
Original	Adjusted	
22-2-21 Mon 23:17:05	24 Feb 2021 Wed 11:23:53	Flash (Camera 8)
22-2-21 Mon 23:17:45	24 Feb 2021 Wed 11:24:33	Flash (Camera 8)
22-2-21 Mon 23:18:15	24 Feb 2021 Wed 11:25:03	Flash (Camera 7)

⁵⁹² S-283 (Dr Salim’s Report), p. 12, Table 1.

⁵⁹³ S-288 (SCDF’s Investigation Report), pp. 12-15, Screenshots 24, 31 and 33.

285 Cameras 7 and 8 were located within Unit 32E belonging to Alif-E, as shown in Annex H of SCDF's Investigation Report.⁵⁹⁴

(a) *Experts' positions on the cause of the three flashes*

286 Dr Salim has opined that the flashes were indicative of three flash fires without significant overpressures. The fires were likely to be caused by potato starch powder found at the Tuas Site, which was the only known combustible material⁵⁹⁵ present in significant quantities apart from the thermic oil.⁵⁹⁶ Dr Salim further indicated that the analysis of samples taken from various locations in the Tuas Site showed that starch was present in all these samples.⁵⁹⁷ This pointed to the likelihood that significant quantities of potato starch may have accumulated on various surfaces throughout the Tuas Site and on the surfaces of the Platform.⁵⁹⁸

287 SCDF has opined that these flashes were most likely dust cloud explosions caused by the ignition of potato starch powder that was suspended in the air after the rupture of the Mixer Machine and the initial fire, as there were no other

⁵⁹⁴ S-288 (SCDF's Investigation Report), Annex H, p. H-3.

⁵⁹⁵ S-283 (Dr Salim's Report), p. 45.

⁵⁹⁶ S-283 (Dr Salim's Report), p. 13:6-11.

⁵⁹⁷ S-283 (Dr Salim's Report), p. 49, Table 10.

⁵⁹⁸ S-283 (Dr Salim's Report), p. 51:20-24.

competent fuels within the vicinity which could have resulted in the flash fires/explosions seen.⁵⁹⁹

288 Hawkins initially indicated that there was no evidence that there had been multiple explosions,⁶⁰⁰ though this was before Dr Rose had an opportunity to see the CCTV footages from Alif-E. Dr Rose asserted that there was no evidence to suggest that there was an accumulation of dust inside the unit, and that horizontal surfaces and inaccessible areas/corners inside the Tuas Site were free from significant deposits⁶⁰¹ during Hawkins' inspection of the Tuas Site on 15 March 2021.⁶⁰² Photographs 7 to 9 in the Hawkins Report were produced to support the position that the production area at the Tuas Site was generally dust-free.⁶⁰³

289 During the Inquiry hearing, Dr Rose stated that the flashes were indicative of ignition of smoke plumes instead.⁶⁰⁴ Dr Rose explained that oils and heavy hydrocarbons are difficult to burn till completion, and the resultant smoke plume could be 500°C and above.⁶⁰⁵ The turbulence could result in pockets of air and fuel

⁵⁹⁹ S-288 (SCDF's Investigation Report), p. 19, [8(o)].

⁶⁰⁰ ST-1 (Hawkins Report), [6.1.1].

⁶⁰¹ ST-1 (Hawkins Report), [4.3.5].

⁶⁰² ST-1 (Hawkins Report), [1.5].

⁶⁰³ ST-1.

⁶⁰⁴ NE 6 October 2021, p. 70:10-11 (Dr Rose EIC).

⁶⁰⁵ NE 6 October 2021, p. 70:17-23 (Dr Rose EIC).

mixture which are perfect for combustion, resulting in localised combustion of the smoke plumes within Alif-E's unit.⁶⁰⁶

290 The IC should find that the flash fires were most likely caused by the ignition of potato starch from the Tuas Site, for the following reasons:

(a) This is consistent with the lack of proper practices for dealing with combustible dusts at the Tuas Site workshop;

(b) There was potato starch found in all the samples analysed after the incident; and

(c) The ignition of smoke plumes from the incomplete combustion of the thermic oil is speculative and not in line with Maj Huang's experience.

(b) The lack of proper practices for combustible dusts at the Tuas Site created pockets of potato starch to be ignited

291 SS667: "The Code of Practice for the handling, storage and processing of combustible dust" ("**SS 667**") states that dust flash fire or explosion hazards exists in areas where the dust accumulation is greater than 0.8mm in depth.⁶⁰⁷

⁶⁰⁶ NE 6 October 2021, pp. 70:24-71:16 (Dr Rose EIC).

⁶⁰⁷ S-283 (Dr Salim's Report), p. 46:11-13.

292 There was a lack of proper dust-control measures and practices implemented at the Tuas Site workshop. In particular, the exhaust ventilation deployed at the workshop was woefully inadequate to deal with dust, and the workers' housekeeping routine, which primarily involved sweeping with brooms and using an air compressor gun to spray dust off table-tops and surfaces, would have tended to create more dispersions of dust particles.⁶⁰⁸ The inadequacy of the ventilation measures at the Tuas Site and the housekeeping practices which were not suitable for dust control gave rise to ample opportunities for pockets of potato starch to accumulate, such that it became a flash fire or explosion hazard. We return to this at [409]-[411] below.

(c) *The presence of potato starch in the samples analysed after the incident*

293 As stated above at [286], the analysis of samples taken from various locations in the Tuas Site showed that starch was present in all these samples.⁶⁰⁹ This pointed to the likelihood that significant quantities of potato starch may have accumulated on various surfaces throughout the Tuas Site and on the surfaces of the Platform.⁶¹⁰

⁶⁰⁸ S-233, p. 2.

⁶⁰⁹ S-283 (Dr Salim's Report), p. 49, Table 10.

⁶¹⁰ S-283 (Dr Salim's Report), p. 51:20-24.

294 Dr Rose has attempted to minimise the relevance of these analyses, in stating that he had not seen accumulations of dust during his site visit, notwithstanding the fact that there were piles of powdery substances throughout the Tuas Site. Dr Rose has also asserted that evidence of dust should be taken from “*nooks and crannies*” further away from the areas affected by the explosion,⁶¹¹ as the general surfaces would be affected by sprinklers and subsequent human traffic.⁶¹²

295 MOM and Dr Salim had in fact taken this into account, in the choice of locations to take samples from. As explained by Ms Lim, one of the samples was taken from an area right outside the toilet of the Tuas Site, underneath a pallet.⁶¹³ This was because this was an area which would be untouched by people, and largely unaffected by firefighting responses, hence satisfying the criterion of being a “*nook and cranny*” in Dr Rose’s words.⁶¹⁴

296 Ms Lim confirmed that starch was found in this sample collected,⁶¹⁵ and that the starch found at this location would have reflected the starch being there before the Accident, and not disturbed by subsequent post-Accident measures taken.⁶¹⁶ Ms

⁶¹¹ NE 6 October 2021, p. 17:1-18:3 (Dr Rose EIC).

⁶¹² NE 6 October 2021, p. 170:10-171:15 (Dr Rose EIC).

⁶¹³ S-289 (MOM’s Investigation Report), p. 30.

⁶¹⁴ NE 7 October 2021, p. 121:12-21 (Ms Lim EIC).

⁶¹⁵ NE 7 October 2021, p. 121:16-24 (Ms Lim EIC).

⁶¹⁶ NE 7 October 2021, pp. 122:24-124:7 (Ms Lim EIC).

Lim further opined that the presence of starch in *all* the samples taken, as shown in Table 10 of Dr Salim's Report,⁶¹⁷ even after the fire (which would have consumed starch), and after firefighting efforts, reflects that there was clearly potato starch present around the workshop prior to the Accident.⁶¹⁸

(d) The ignition of smoke plumes from the incomplete combustion of the thermic oil is speculative and not in line with Maj Huang's experience

297 Finally, the ignition of smoke plumes from the incomplete combustion of thermic oil is highly speculative, and not in line with the experience of Maj Huang in dealing with industrial fires.

298 As explained by Dr Salim, while it was potentially possible for smoke plumes to ignite,⁶¹⁹ there was no evidence or data to support the ignition of smoke plumes during the Accident, as one does not know the composition of the smoke plumes, such that he would be speculating.⁶²⁰ There was no sample available, and no information on the amount, and the duration of materials in the smoke plume for him to make a conclusive determination on whether it was likely for the smoke

⁶¹⁷ S-283 (Dr Salim's Report), p. 49.

⁶¹⁸ NE 7 October 2021, p. 122:5-19 (Ms Lim EIC).

⁶¹⁹ NE 5 October 2021, pp. 126:24-127:2 (Dr Salim Re-ex).

⁶²⁰ NE 5 October 2021, p. 127:2-5 (Dr Salim Re-ex)

plumes to have ignited, since combustibility was highly dependent on the material itself.⁶²¹

299 This is supported by the evidence of Maj Huang during the Inquiry hearing. When asked to comment on Photographs 7 to 9 in the Hawkins Report, Maj Huang candidly stated that he was unable to tell what the level of dust was within the Tuas Site from these photographs.⁶²² Maj Huang also opined that while there was no distinctive burn pattern for flash fires, there could be surfaces or easily combustible materials that would have melting, charring or signs of heat damage in pockets around the room, and this was observed in both the Tuas Site and Alif-E's unit.⁶²³

300 Maj Huang confirmed that potato starch, being a known combustible powder, when suspended in air could ignite once the fuel/air mixture reaches the right mixture and is in contact with an ignition source, hence the flashes of fire as shown on the CCTV footage occurring at random times.⁶²⁴ Depending on where the right fuel/air mixture is located and ignited *vis-à-vis* the location of the relevant CCTV camera, and depending on whether there are any visual obstructions such as thick smoke, it is possible that one CCTV camera captures only one flash fire and another CCTV camera captures only a different flash fire.⁶²⁵ According to Maj

⁶²¹ NE 5 October 2021, pp. 127:23-128:6 (Dr Salim Re-ex).

⁶²² NE 7 October 2021, pp. 87:6-88:11 (Maj Huang EIC).

⁶²³ NE 7 October 2021, pp. 85:8-86:9 (Maj Huang EIC).

⁶²⁴ NE 7 October 2021, pp. 110:18-111:20 (Maj Huang, questions from IC).

⁶²⁵ NE 7 October 2021, pp. 80:7-81:11 (Maj Huang EIC).

Huang, this could explain why on 24 February 2021, the first two flash fires were only captured by Camera 8 and not Camera 7 and the third flash fire was captured only by Camera 7 and not Camera 8 (see [284] above).⁶²⁶ Maj Huang explained that it was possible that the flash fires captured on Camera 7 and Camera 8 were the result of potato starch travelling from the Tuas Site workshop into Unit 32E belonging to Alif-E and igniting at different locations close to Camera 7 or Camera 8 (as the case may be).⁶²⁷ It was equally possible that there were other flash fires inside the Tuas Site workshop that were not captured by either Camera 7 or Camera 8.⁶²⁸

301 As regards the possibility of the ignition of smoke plumes inside Alif-E's Unit 32E, Maj Huang explained that in his experience as a fire investigator, and as a commander of a fire station dealing mostly with industrial fires,⁶²⁹ he has not seen any fire within a building where the smoke catches fire again, as the smoke would usually leave the affected premises and be dispersed, such that it would be much harder to form the right mixture again to ignite.⁶³⁰

302 The IC is faced with two competing theories: one involving a known combustible dust in the form of potato starch, which was found throughout the Tuas

⁶²⁶ NE 7 October 2021, pp. 80:7-81:11 (Maj Huang EIC).

⁶²⁷ NE 7 October 2021, pp. 83:12-85:4 (Maj Huang EIC).

⁶²⁸ NE 7 October 2021, pp. 86:10-87:5 (Maj Huang EIC).

⁶²⁹ S-288A, NE 7 October 2021, p. 62:13-21 (Maj Huang EIC).

⁶³⁰ NE 7 October 2021, p. 112:5-11 (Maj Huang, questions from IC).

Site, including an undisturbed area beneath a pallet right outside Stars' toilet, and a speculative theory proffered by Hawkins only during the Inquiry hearing itself, which is not supported by any data or the practical observations by an experienced firefighter and fire investigator. It is most likely that there were subsequent flash fires caused by the suspension of potato starch powders around the Tuas Site workshop, than by hydrocarbons within the smoke plumes created by the incomplete combustion of thermic oil. Such a finding would be consistent with the inadequate ventilation and housekeeping measures at the workshop by Stars for dust control (see [410]-[412] below), which created the environment for potato starch to accumulate throughout the workshop.

B. The root causes

303 The proximate technical causes discussed above describe the Accident triggers on 24 February 2021. These triggers were present on 24 February 2021 due to a series of failures by Stars from as early June 2020 when the Mixer Machine was commissioned. These failures go to the root causes of the Accident and are described below in turn.

1. Stars failed to establish the safe working parameters for operating the Mixer Machine

304 Stars failed to establish the safe working parameters for operating the Mixer Machine. Stars should have done this at the very beginning when commissioning the Mixer Machine.

305 Chua XD explained that throughout the many months Stars was producing fire clay with the Mixer Machine, the workers were continually experimenting with the temperature settings to heat the contents of the mixing chamber.⁶³¹ And even as the temperature settings were being experimented with, the oil jacket temperature was never monitored and the pressure within the oil jacket was also not monitored (see [39(d)] above). This was unsafe.

306 Prof Chew explained, at the Inquiry hearing, the importance of the machinery commissioning stage:⁶³²

“...if [the operator] does a proper calibration of the machine during the commissioning stage he will know exactly how the machine should behave, okay. Set at what temperature, wait for how long, the

⁶³¹ SS-6 (Chua XD), [144]; NE 23 September 2021, p. 189:10-21 (Chua XD EIC).

⁶³² NE 7 October 2021, p. 35:14-22 (Prof Chew XX).

content temperature will be able to reach the temperature required, maybe 80 or 90 degrees, he should know all this data beforehand.

So after he had this type of thing, if anything abnormal, he should be able to pick up straightaway.”

307 It is envisaged that by the end of the commissioning stage, the operator of the machine would have understood the various functionalities of the machine, how to operate the machine to achieve the intended outcome, and what circumstances would be considered abnormalities that require investigation.

308 However, in Stars’ case, Chua XD took the commissioning of the Mixer Machine as completed on 12 June 2020 (see [72]-[73] above). This was even though water, and not oil, had been used in the oil jacket, and the following issues had not yet been determined:

- (a) The volume of oil required in the oil jacket;
- (b) The temperature setting for the oil jacket; and
- (c) The indicative timing for the required oil and water temperatures to be reached.

309 Chua XD also had a poor grasp of/cavalier attitude towards:

- (a) The functionality of both RTDs; and
- (b) The functionality of the Back Pipe/vent port.

310 It is telling that none of the issues above feature in Stars' Safe Work Procedure ("SWP") for making fire wrap.⁶³³ If the above issues had been properly determined at the commissioning stage and incorporated into Stars' SWP for making fire wrap, and shared with the Stars workers, Stars would have established safe working parameters for operating the Mixer Machine. Instead, as described below, Stars made three critical missteps as regards the operation of the Mixer Machine.

- (a) *Stars operated the Mixer Machine with insufficient oil in the oil jacket*

311 The impact of not using sufficient oil on temperature and pressure within the oil jacket has been described above at [239]. The consequences are severe where less than 222L (*ie*, where there will be void space between the oil's surface and the W-shaped mixing chamber base) is used.⁶³⁴

⁶³³ S-264.

⁶³⁴ S-283 (Dr Salim's Report), pp. 23:22-24:4.

312 Chua XD understood that the oil in the oil jacket needed to be in contact with the surfaces of the mixing chamber. This was so that the heat energy from the oil would be transferred through contact with the mixing chamber's surfaces to heat the contents in the mixing chamber.⁶³⁵ He understood this on 12 June 2020, when commissioning and testing the Mixer Machine, without having to read the User Guide.⁶³⁶ This is consistent with Prof Chew's view that it is common sense that minimally, the user should fill enough oil to cover the heaters and have the oil contact a significant part of the mixing chamber's surfaces.⁶³⁷

313 On 12 June 2020, Chua XD had used water as the heat transfer medium in the jacket. He felt that something was not right with his use of water, and read the User Guide very shortly thereafter, around 12 June 2020.⁶³⁸ He claimed that he understood the User Guide's reference to adding fuel to "*half the height of the cylinder*"⁶³⁹ to be synonymous with "half-height" of the oil jacket and to correspond to his black marking on the photograph of the Mixer Machine (S-282).⁶⁴⁰

314 However, after learning that oil should be used in the oil jacket, Chua XD chose to only purchase 2 buckets of oil (20L each) for use in the oil jacket on 16

⁶³⁵ NE 23 September 2021, pp. 134:18-135:6 (Chua XD EIC).

⁶³⁶ NE 23 September 2021, p. 135:7-10 (Chua XD EIC).

⁶³⁷ S-290 (Prof Chew's Report), [3.2.2].

⁶³⁸ NE 23 September 2021, p. 131:9-25 (Chua XD EIC).

⁶³⁹ S-271, p. 5, Section Ten.

⁶⁴⁰ NE 23 September 2021, pp. 138:1-139:17 (Chua XD EIC).

June 2020 (see [77] above). This was notwithstanding Chua XD's own allegation that at least 6 buckets of water (20L each) had been used in the oil jacket on 12 June 2020,⁶⁴¹ and his own purported understanding of where the "half-height" of the cylinder/oil jacket (up to which oil should be added) came up to (as seen in S-282).

315 Chua XD admitted that a simple back of envelope calculation (which he could have done for himself at the time⁶⁴²) would have shown that to fill even just the vertical section of the oil jacket's base (before the curvature of the oil jacket begins) would require 152L of oil,⁶⁴³ and that even more would be required to fill the oil jacket to what he himself had purportedly considered to be its half-height.⁶⁴⁴ Instead, Chua XD chose to use only 40L of oil on 16 June 2020. There was no explanation for this other than 40L being a "*random figure [he] landed on*".⁶⁴⁵

⁶⁴¹ NE 27 September 2021, p. 184:2-22 (Chua XD Re-ex).

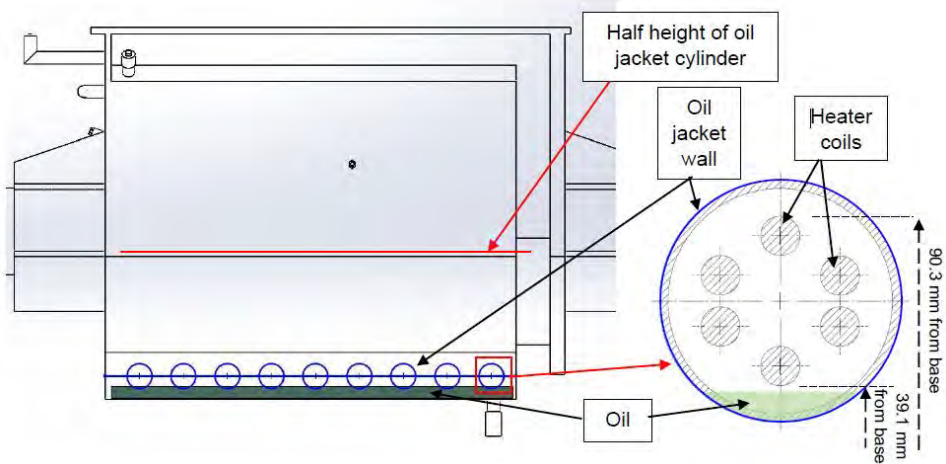
⁶⁴² NE 23 September 2021, p. 153:1-4 (Chua XD EIC).

⁶⁴³ NE 23 September 2021, p. 152:1-20 (Chua XD EIC).

⁶⁴⁴ NE 23 September 2021, p. 153:5-12 (Chua XD EIC).

⁶⁴⁵ NE 23 September 2021, p. 148:8-11 (Chua XD EIC).

316 As regards the 40L of oil used on 16 June 2020, professional modelling by Matcor showed that it was patently inadequate – the oil would have *barely* touched the base of the heaters:⁶⁴⁶



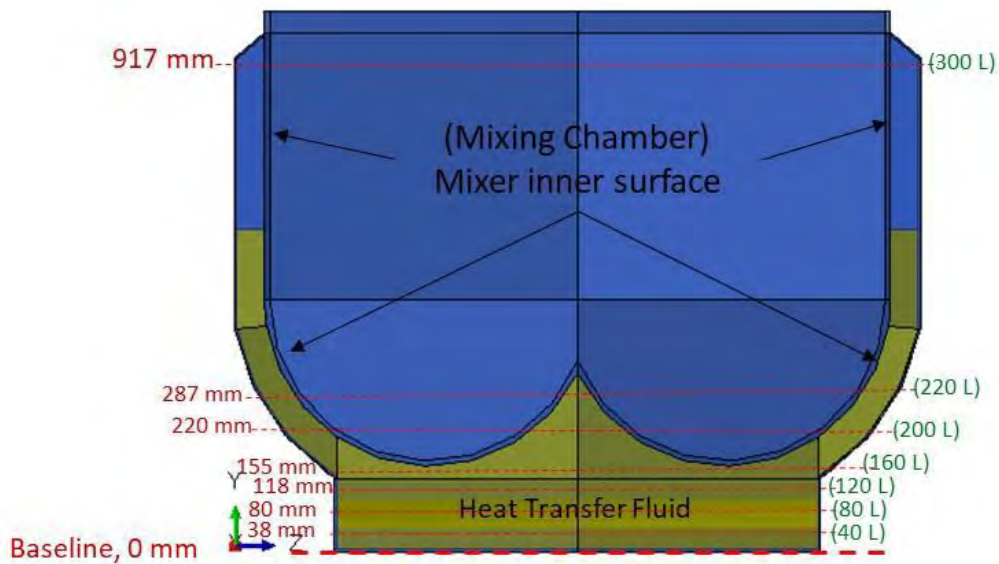
317 After 16 June 2020, Stars similarly never used sufficient oil in the Mixer Machine's oil jacket. For example:

- (a) When 80L of oil was purchased on 8 August 2020 (see [88] above), the best-case scenario (assuming the full 80L were added to the full 40L from 16 June 2020) is 120L of oil in the oil jacket; and
- (b) When another 80L of oil was purchased on 5 February 2021 (see [123] above), the best-case scenario (assuming 40L were added to the full

⁶⁴⁶ S-279 (Matcor Report), p. 158 – Figure 212.

120L assumed at [317(a)] above – bearing in mind that 2 buckets (20L each) were unused) is 160L of oil in the oil jacket.

318 Having regard to the back of envelope calculation (see [315] above), 120L of oil would not fill the vertical section of the oil jacket and 160L would be barely enough to fill the vertical section of the oil jacket. Neither scenario would see the oil level reach what Chua XD considered to be “half-height” of the oil jacket.⁶⁴⁷ This was confirmed by professional modelling done by Dr Salim of various oil fill levels:⁶⁴⁸



⁶⁴⁷ NE 23 September 2021, p. 158:12-18 (Chua XD EIC).

⁶⁴⁸ S-283 (Dr Salim’s Report), p. B.8, Figure B.6.

319 Based on Dr Salim’s professional modelling, more than 222L of oil was required to ensure full contact with the surfaces of the mixing chamber.⁶⁴⁹ This coheres with the guidance in the User Guide that oil should be filled up to “*half the height of the cylinder*”,⁶⁵⁰ which Matcor estimated to come up to at least 245L of oil.⁶⁵¹

320 A simple check on the oil fill level in the oil jacket at any point in time between 16 June 2020 to 24 February 2021 would have revealed to Chua XD that there was insufficient oil. Prof Chew explained that a simple check using a dipstick that touched the bottom of the oil jacket would do the trick.⁶⁵²

321 Chua XD admitted that Stars in fact had such a dipstick which Stars used to check on the oil level.⁶⁵³ Nasim used it on 7 August 2020, when it showed that the oil fill level was about one and a half inches from the bottom of the oil jacket (see [79] above). In fact, Chua XD admitted on examination that he had already known then that the amount shown on the dipstick on 8 August 2020 was showing the amount left in the oil jacket from the very bottom of the oil jacket.⁶⁵⁴ Chua XD also used the dipstick occasionally during his monthly maintenance checks, when it

⁶⁴⁹ S-283 (Dr Salim’s Report), pp. 23:22-24:4.

⁶⁵⁰ S-271, p. 5, Section Ten.

⁶⁵¹ S-279 (Matcor Report), p. 23:10-18.

⁶⁵² NE 7 October 2020 p. 17:5-18 (Prof Chew XX).

⁶⁵³ NE 23 September 2021, pp. 163:6-164:4 (Chua XD EIC).

⁶⁵⁴ NE 23 September 2021, p. 163:6-14 (Chua XD EIC).

usually showed that the oil fill level was about four to five inches from the bottom of the oil jacket.⁶⁵⁵ It is undisputed that even at five inches, the oil level would not be sufficient to make contact with the mixing chamber surfaces.⁶⁵⁶

322 There is no explanation why Chua XD chose to purchase so little oil and use even less in the oil jacket. Chua XD had the means to ascertain how much oil was needed in the oil jacket and to ensure the same. But he failed to do so.

(b) Stars operated the Mixer Machine without monitoring the temperature of the oil in the oil jacket

323 As stated above at [39(d)], Stars did not monitor the temperature of the oil in the oil jacket. Chua XD did not think it was required for production of the fire clay.⁶⁵⁷

324 Chua XD was aware that the oil jacket had an operating temperature range of 70°C to 160°C and a design temperature of 200°C, as stated in the User Guide.⁶⁵⁸ He was also aware that the Mixer Machine came with two RTDs, one for the oil jacket temperature and one for the mixing chamber.⁶⁵⁹ He was aware which fixtures

⁶⁵⁵ SS-6 (Chua XD), [72]; NE 23 September 2021, pp. 164:9-165:7 (Chua XD EIC).

⁶⁵⁶ NE 23 September 2021, p. 165:8-15 (Chua XD EIC).

⁶⁵⁷ SS-6 (Chua-XD), [82].

⁶⁵⁸ NE 23 September 2021, pp. 171:15-173:23 (Chua XD EIC); S-271, p. 4, Section Eight.

⁶⁵⁹ SS-6 (Chua-XD), [82].

on the Mixer Machine the RTDs could be attached to.⁶⁶⁰ He claimed that he was unaware that only the RTD for the oil jacket operated on an interlock system. He assumed that both RTDs operated on an interlock system but that the interlock system did not work all the time, which led him to instruct the workers to manually turn off the heaters when the required temperature for the contents of the mixing chamber was reached.⁶⁶¹

325 Chua XD accepted that to ensure that the oil jacket temperature was kept within the operating and design temperature ranges, the temperature of the oil in the oil jacket ought to be measured.⁶⁶² He was also aware that measuring the temperature of the contents in the mixing chamber alone would not give an indication of the temperature of the oil in the oil jacket, especially if the oil in the oil jacket was not making good contact with the surface of the mixing chamber.⁶⁶³ And as explained above at [315]-[321], Chua XD ought to have known that there was never sufficient oil in the oil jacket to make good contact with the surface of the mixing chamber. Yet, Chua XD did not require Stars' workers to monitor the temperature of the oil in the oil jacket. Chua XD provided two explanations for this.

⁶⁶⁰ NE 23 September 2021, pp. 184:21-185:7 (Chua XD EIC).

⁶⁶¹ NE 23 September 2021, pp. 187:20-189:8 (Chua XD EIC).

⁶⁶² NE 23 September 2021, p. 174:4-20 (Chua XD EIC).

⁶⁶³ NE 23 September 2021, pp. 175:18-176:22 (Chua XD EIC).

326 The first explanation was that he assumed that the oil in the oil jacket could only ever be heated up to a temperature of 160°C as he always had the perception that this was the upper limit of the Mixer Machine’s heating capacity.⁶⁶⁴ However, there was no basis for Chua XD to have assumed this. When queried by counsel for Stars on why he assumed this, Chua XD referred to the User Guide.⁶⁶⁵

Examination of Chua XD by Counsel for Stars

Q. This goes to what you have said several times so far, that **you believed that there would be the presence of this controller or a fail safe, so to speak, in the mixer machine ensuring that the operating temperature would not go beyond 160 degrees, yes?**

A. Yes, your Honour.

Q. In fact, based on my understanding of what you’ve said so far, it appears that it is this belief of yours that determined how you operated the mixer machine. Is that a fair statement?

A. Yes, your Honour.

Q. I need to ask you this: **what made you think that such a fail safe or controller existed in the mixer machine?**

A. **According to the user guide, section 5, so this, they actually state this machine come with a temperature -- digital temperature controller for the process.**

⁶⁶⁴ NE 23 September 2021, p. 172:6-23; p. 184:6-11 (Chua XD EIC).

⁶⁶⁵ NE 27 September 2021, pp. 83:24-84:19 (Chua XD XX).

Q. Is that all?

A. Yes. Yes, your Honour.

(emphasis in added)

327 But the User Guide simply states that the Mixer Machine came with a “*digital display temperature control*”⁶⁶⁶ – plainly a reference to the digital display panels on the control panel which displayed the temperatures of the oil jacket and the mixing chamber as measured by their respective RTDs. The very fact that the Mixer Machine came with equipment to measure and monitor the temperatures of the oil jacket and the mixing chamber should have made it clear that both temperatures ought to have been measured and monitored during operation.

328 The second explanation was that Chua XD had monitored the temperature of the water in the oil jacket on 12 June 2020 (by dropping an RTD into the oil jacket through the Front Pipe) and was satisfied that the water would not be heated up beyond 160°C.⁶⁶⁷ However, the obvious issue, accepted by Chua XD, was that the temperature measurement on 12 June 2020 was of water, which would give a different reading as compared to oil.⁶⁶⁸ Moreover, it does not follow that a one-time reading on 12 June 2020 can confirm that the temperature would never go above 160°C. In fact, Chua XD conceded that the safe way to operate the Mixer Machine

⁶⁶⁶ S-271, p. 3, Section Five.

⁶⁶⁷ NE 23 September 2021, pp. 180:5-182:20 (Chua XD EIC).

⁶⁶⁸ NE 23 September 2021, pp. 182:21-183:2 (Chua XD EIC).

would require that the oil jacket temperature be monitored each time the Mixer Machine was used.⁶⁶⁹

329 Chua XD could have easily monitored the oil jacket temperature using the RTD for the oil jacket that came with the Mixer Machine. Dr Rose from Hawkins accepted that the RTD for the oil jacket was one way of monitoring the oil temperature though he noted that the location of its fixtures on the Mixer Machine were above the oil level in the oil jacket.⁶⁷⁰ But this is no reason not to monitor the oil temperature. On the contrary, it would have been easy to monitor the oil temperature:

(a) It was always open to Stars to fill the oil jacket up to the relevant fixture locations, to obtain more accurate oil temperature readings.⁶⁷¹

(b) Dr Salim also explained that even if oil was not filled up to the relevant fixture locations but at least until there was full contact with the surface of the mixing chamber (*eg*, 230L), the RTD for the oil jacket would have been able to adequately register high temperatures and could trigger the interlock system when beyond-safe temperatures were reached.⁶⁷²

⁶⁶⁹ NE 23 September 2021, p. 183:13-19 (Chua XD EIC).

⁶⁷⁰ NE 6 October 2021, pp. 111:21-112:25 (Dr Rose XX).

⁶⁷¹ NE 7 October 2021, p. 16:10-18 (Prof Chew EIX).

⁶⁷² S-283 (Dr Salim's Report), p. 17:12-21.

(c) If the oil level was far too low, Stars could have dropped the RTD for the oil jacket directly into the oil jacket through the Back Pipe or Front Pipe (as Chua XD did on 12 June 2020). Stars could also have used a commercially available infrared temperature gun to measure the temperature at the desired location of the oil jacket, which according to Dr Rose from Hawkins could have been easily done.⁶⁷³

330 Notwithstanding all of the above, Chua XD decided to close the Back Pipe and Front Pipe (see [90] above), and install insulation over the oil jacket (see [124] and [163] above), effectively removing the ability to measure the temperature of the oil in the oil jacket.

331 If Stars had instead monitored the temperature of the oil in the oil jacket, it would have realised that the temperatures within were so high that there was a risk of pressure building up within the oil jacket.

⁶⁷³ NE 6 October 2021, pp. 113:22-114:5 (Dr Rose XX).

(c) *Stars modified the Mixer Machine to operate as a closed system, and it did so without taking appropriate safety measures to guard against pressure build-up*

332 As explained above at [39(c)], when the Mixer Machine was delivered, only the Front Pipe was closed with an end cap. The Back Pipe was fitted with the blue funnel that came with the Mixer Machine, for the pouring in of oil.

333 However, Chua XD instructed his workers to close both the Front Pipe and the Back Pipe.⁶⁷⁴ He told Imam to do so in the wee hours of 8 August 2020 after being informed that the oil in the oil jacket had run out (see [80] above). Chua XD wanted both the Front Pipe and Back Pipe closed as he was concerned about the evaporation of the oil from the pipes if they were left open.⁶⁷⁵ Chua XD was acutely aware of the cost considerations if the evaporation of oil led to Stars needing to purchase oil more frequently. When he contacted MHT (Sharon) on 8 August 2020 via WhatsApp to make an order for oil (see [81] above), he expressed concerns about the price of the oil:⁶⁷⁶

Chua XD: *“Pls give me better price”*

Chua XD: *“I will need to buy these oil Long term, as I keep using for my production”*

⁶⁷⁴ SS-7 (Moe), [25].

⁶⁷⁵ NE 24 September 2021, pp. 32:14-33:12 (Chua XD EIC).

⁶⁷⁶ S-5, IM#40-53.

...

Chua XD: “4 bucket can cheaper?”

Sharon Lee: “Already reduced for you..”

Chua XD: “Very expensive leh sister , can give better price ?”

Sharon Lee: “130 reduced to 125”

Chua XD: “**Every 1 mth I need to buy 1 time**”

(emphasis added)

334 Ultimately, Chua XD did not buy oil every month. Stars operated the Mixer Machine as a closed system (*ie*, with the Front Pipe and Back Pipe closed) henceforth, and the next purchase of oil was almost six months later on 5 February 2021 (see [123] above).

335 In his witness statement, Chua XD stated that he thought that the Mixer Machine was supposed to be operated as a closed system. At the Inquiry hearing, however, Chua XD conceded that he thought the Mixer Machine could be operated either as an open system or a closed system, and that he chose to operate it as a closed system.⁶⁷⁷

336 However, there was no basis for Chua XD to have thought that the Mixer Machine could have been operated as a closed system.

⁶⁷⁷ NE 24 September 2021, pp. 35:10-36:2 (Chua XD EIC).

337 First, as explained above, the Mixer Machine only came with one end cap for the Front Pipe. The User Guide⁶⁷⁸ gave no instructions on closing the Back Pipe. On the contrary, the User Guide states that there is “*an oil vapor vent... provided at the highest point behind the machine*”,⁶⁷⁹ which suggests strongly that the Back Pipe is to be kept open to allow venting.

338 Second, Chua XD claimed that page 5 of the User Guide⁶⁸⁰ which states “*When refueling, you need to open one side vent hole and add [oil] ...*” is guidance that the Back Pipe is to be closed.⁶⁸¹ But those instructions simply illustrate that oil is to be added through the open vent hole (*ie*, the Back Pipe). Importantly, insofar as Chua XD associated the “*vent hole*” with the Back Pipe, he would have known that it was intended to be open to allow venting of oil vapours (see [337] above). When this was put to Chua XD, he inconsistently attempted to deny that he had associated the “*vent hole*” with the Back Pipe.⁶⁸²

339 Third, Prof Chew’s expert opinion is that the design of the Mixer Machine is not meant for operating as a closed system. He explained that the Back Pipe should be opened to allow oil vapours to escape to prevent the building of pressure

⁶⁷⁸ S-271.

⁶⁷⁹ S-271, p. 4, Section Eight.

⁶⁸⁰ S-271.

⁶⁸¹ SS-6 (Chua XD), [124].

⁶⁸² NE 24 September 2021, p. 25:7-23 (Chua XD EIC).

in the oil jacket.⁶⁸³ Further, Prof Chew saw no reason to operate the Mixer Machine as a closed system given that a closed system would not enhance the heat transfer from the oil in the oil jacket to the contents of the mixing chamber.⁶⁸⁴

340 Fourth, Chua XD and Dr Rose of Hawkins state that the oil jacket's working pressure of $\leq 0.2\text{Mpa}$ as stated in the User Guide (see [40(c)] above)⁶⁸⁵ suggested that the Mixer Machine could operate under pressure as a closed system.⁶⁸⁶ But this is no more than an indication of the upper limit of pressure that the oil jacket can withstand. It should not be construed as an instruction to operate the oil jacket at a pressure of 0.2Mpa .

341 Fifth, Chua XD attempted to explain at the Inquiry hearing that the Mixer Machine ought to be operated as a closed system to prevent oxidisation of the oil in the oil jacket given guidance in the oil specification sheet that there is a greater risk of oil oxidation in open systems.⁶⁸⁷ But this was a belated attempt that had no foundation. Chua XD had read the oil specifications as early as 16 June 2020 yet gave no instructions to close the Back Pipe between 16 June 2020 to 8 August 2020.⁶⁸⁸ Moreover, the oil specifications sheet provided that the recommended

⁶⁸³ S-290 (Prof Chew's Report), [3.3.2]-[3.3.5].

⁶⁸⁴ S-290 (Prof Chew's Report), [3.3.8]; NE 7 October 2021, pp. 19:13-21:5 (Prof Chew EIC).

⁶⁸⁵ S-271, p. 4, Section Eight.

⁶⁸⁶ SS-6 (Chua XD), [124]; NE 6 Oct 2021, p. 118:7-23 (Dr Rose EIC).

⁶⁸⁷ NE 24 September 2021, p. 10:12-21 (Chua XD EIC); S-53.

⁶⁸⁸ NE 24 September 2021, p. 12:6-16 (Chua XD EIC).

operating temperature range was 200°C in an open system,⁶⁸⁹ which was in any event within the operating range of the Mixer Machine.

342 Finally, the manufacturer of the Mixer Machine, Laizhou Keda, has explained that the Mixer Machine is not intended to be operated as a closed system and that the Back Pipe should be kept open.⁶⁹⁰

343 Having decided to operate the Mixer Machine as a closed system, Chua XD compounded the error by failing to take adequate measures to ensure the safe operation of the Mixer Machine in a closed setting.

344 It is undisputed that if operating the Mixer Machine as a closed system, it is critical to monitor and manage the pressure inside the oil jacket. Prof Chew explained that if the Mixer Machine was to be used as a closed system, the user would need to monitor the pressure and/or rely on a pressure relief valve.⁶⁹¹ Otherwise there would be a risk of explosion from a build-up of pressure within the oil jacket.⁶⁹² Dr Rose of Hawkins explained that if the Mixer Machine was a closed system, one would expect the Back Pipe to have a pressure relief valve.⁶⁹³ Chua XD admitted that by operating the Mixer Machine as a closed system he had created a

⁶⁸⁹ S-53.

⁶⁹⁰ S-293A (Laizhou Keda's answers), [11]-[16(b)].

⁶⁹¹ NE 7 October 2021, p. 21:5-11 (Prof Chew EIC).

⁶⁹² NE 7 October 2021, pp. 24:8-26:11 (Prof Chew EIC).

⁶⁹³ NE 6 October 2021, p. 120:14-23 (Prof Chew EIC).

pressure vessel and that as a result, it was important to monitor the pressure inside the oil jacket.⁶⁹⁴ Yet, Stars failed to do so when operating the Mixer Machine.⁶⁹⁵

345 Chua XD had no good reason for Stars’/his failure to monitor the pressure inside the oil jacket:

(a) His first reason was that the Mixer Machine did not come with a pressure gauge.⁶⁹⁶ However, it was open to Stars to purchase a commercially available pressure gauge and attach it to the Back Pipe. Chua XD accepted that it would have been easy to do.⁶⁹⁷

(b) His second reason was that he expected that there would be no pressure build up within the oil jacket as he assumed that that the oil in the oil jacket would never be heated up beyond the oil’s recommended operating temperature of 300°C (as stated in the oil specifications sheet⁶⁹⁸).⁶⁹⁹ However, as demonstrated at [326] above, Chua XD had no basis to make such an assumption about the temperatures inside the oil jacket.

⁶⁹⁴ NE 24 September 2021, p. 36:3-12 (Chua XD EIC).

⁶⁹⁵ SS-6 (Chua XD), [124].

⁶⁹⁶ NE 24 September 2021, p. 36:23-24 (Chua XD EIC).

⁶⁹⁷ NE 24 September 2021, p. 38:5-9 (Chua XD EIC).

⁶⁹⁸ S-272.

⁶⁹⁹ NE 24 September 2021, pp. 38:10-40:16 (Chua XD EIC).

(c) His third reason was that he never saw any physical signs that there was pressure building up within the oil jacket (eg, no oil spraying out from the oil jacket; no bulging or deformation on the oil jacket).⁷⁰⁰ This is plainly untrue. There were several red flags that should have alerted Chua XD to pressure building up within the oil jacket and these are discussed in detail below at [350]-[391].

(d) His fourth reason was that the 0.2 bar maximum working pressure of the Mixer Machine came from Laizhou Keda, and was not Stars' manufacturing requirement.⁷⁰¹ But this is no excuse for irresponsibly failing to check that the maximum working pressure stipulated by the manufacturer was not exceeded during Stars' operation of the Mixer Machine.

346 Ultimately, there is no good explanation for Stars' failure to monitor the pressure inside the oil jacket after having closed the Back Pipe, especially in the light of Chua XD's own admission that Stars was obliged to do so:⁷⁰²

Examination of Chua XD by State Counsel

Q So, Mr Chua, I am just going to say to you – you can tell me if you agree or disagree -- **if someone tells you that these are the safe limits within which your machine should be operated, then you should take the steps to check that**

⁷⁰⁰ NE 24 September 2021, p. 37:2-8 (Chua XD EIC).

⁷⁰¹ SS-6 (Chua XD), [124].

⁷⁰² NE 24 September 2021, pp. 45:23-46:14 (Chua XD EIC).

you're operating within those safe limits. Agree or disagree?

A. **Yes, your Honour, I agree.**

Q. Therefore, when you operate the oil jacket as a closed system and you have accepted earlier already that that creates a pressure vessel in the oil jacket, **for safety reasons, you should be monitoring the pressure inside to make sure it is within the limits specified by your manufacturer. Agree or disagree?**

A. **Yes, your Honour.**

Q. **Agree, right?**

A. **Agree, your Honour.**

(emphasis added)

347 Dr Rose of Hawkins opined that Stars' action of modifying the Mixer Machine to operate as a closed system made no difference to the outcome of the Accident.⁷⁰³ However, this was premised on Hawkins' theory that the rupture of the oil jacket was caused by the chemical explosion within the oil jacket and not due to overpressures within the oil jacket caused by the overheating of thermic oil (see [224] above). As explained above at [225]-[282], we disagree with Hawkins' theory. Stars' action of modifying the Mixer Machine to operate as a closed system did contribute to the overpressures within the oil jacket which eventually led to its rupture.

⁷⁰³ ST-1 (Hawkins Report), [6.3.1].

348 If Stars had not modified the Mixer Machine to operate as a closed system, it is unlikely that there would have been such severe pressure build-up within the oil jacket. Nevertheless, having so modified the Mixer Machine, if Stars had monitored the pressure within oil jacket, it would have realised that pressure was in fact building up within the oil jacket.

2. ***Stars failed to identify and respond appropriately to red flags and near-misses indicating over-heating, pressure build-up, and the oil jacket giving way***

349 Even if Stars did not, at the very outset, appreciate that their failures listed above gave rise to the risk of overheating and overpressure, there were a series of red flags and near-misses that should have alerted Stars to the risk. As explained above at [227], there were multiple observable signs between August 2020 and February 2021 that the Mixer Machine was operating at high temperatures and pressures, and that the oil jacket was giving way. It was obvious that a serious accident involving the Mixer Machine was a likely result. There were ample opportunities for Stars to review how it was operating the Mixer Machine before the occurrence of such an accident. But Stars simply failed to do so. We describe the various red flags and near-misses below.

(a) *Burned heater on 8 August 2020*

350 Following the incident on 8 August 2020 involving the burned heater (see [82]-[87] above), Chua XD instructed Imam to replace the burned heater. Chua XD assumed the heater had burned due to an electrical fault⁷⁰⁴ and considered the matter resolved following the replacement. There was no further investigation as to why the heater had burned.

351 The Mixer Machine had only been installed and commissioned less than two months ago. In that time the Mixer Machine had only been used about five times (including on 12 June 2020). This was a red flag that ought to have been investigated.

352 Chua XD explained that he did not investigate whether the heater had overheated due to high temperatures within the oil jacket.⁷⁰⁵ He allegedly considered that this was unlikely given his baseless assumption that the oil in the oil jacket could only ever be heated up to a temperature of 160°C (see [326] above). However, even a simple investigation would have revealed that the burning of the heater had coincided with the oil running out in the oil jacket the night before. The consequences of not having enough oil in the oil jacket were apparent.

⁷⁰⁴ NE 24 September 2021, pp. 53:20-54:2 (Chua XD EIC).

⁷⁰⁵ NE 24 September 2021, pp. 54:3-55:16 (Chua XD EIC).

353 Moe was also informed of the burned heater on 8 August 2020, and he too did not investigate the issue. He was content to leave the matter with Chua XD.⁷⁰⁶

(b) *Deteriorated gaskets*

354 On 28 August 2020, Imam informed Chua XD via telephone that the Mixer Machine's gaskets were worn out, and Chua XD instructed Imam to replace the gaskets (see [96] above). According to Chua XD, he thought that the gaskets may have already aged by the time they were supplied by the manufacturer.⁷⁰⁷ But the reality was that Chua XD did not personally check the deteriorated gaskets before asking for them to be replaced. It also does not appear that Chua XD knew what the original condition of the gaskets were. No meaningful investigation was conducted into why the gaskets had deteriorated so soon. As explained above, Mr Shandro's view was that this was likely due to high temperatures and accelerated aging of the gaskets during the whole time of operation (see [228] above). Mehedi, for example, considered that the gaskets had been exposed to high heat from the oil jacket (see [95] above). This was another red flag indicating over-heating in the oil jacket.

⁷⁰⁶ NE 30 September 2021, pp. 36:24-38:12 (Moe EIC).

⁷⁰⁷ NE 24 September 2021, p. 113:9-21 (Chua XD EIC).

(c) *Oil drained from the oil jacket was black*

355 There were numerous occasions where the oil inside the oil jacket had turned black in colour (see [94], [109], and [129] above). Chua XD and Moe were aware of this (see [361] below and [110] above), yet there was no investigation into whether this was a normal occurrence. In fact, Moe explained that he was concerned about the oil turning black in colour⁷⁰⁸ but it appears he did nothing to follow-up on his concern.

356 It would have been easy to check with MHT on whether it was normal for the oil to turn black. If Chua XD or Moe had done so, they would have realised that it was not normal. As explained above, Dr Salim stated the oil turning black in colour was indicative of a chemical reaction happening within the oil due to high temperatures (see [229] above). In fact, when Chua XD took a moment's pause to consider the phenomenon at the Inquiry hearing, he acknowledged that this showed that the thermic oil was subject to temperatures higher than 300°C.⁷⁰⁹

⁷⁰⁸ NE 30 September 2021, pp. 50:13-51:18 (Moe EIC).

⁷⁰⁹ NE 27 September 2021, p. 179:4-7 (Chua XD, questions from IC).

(d) *White smoke from the oil jacket*

357 From as early as August/September 2020 to February 2021, there were reports of white smoke coming from the oil jacket when the oil in the oil jacket was being heated (see [97]-[98] and [119]-[122] above).

358 On 8 January 2021, Moe thought that it was oil vapours escaping from hairline cracks on the oil jacket and considered it a safety risk.⁷¹⁰ He reported the matter to Chua XD via WhatsApp and they agreed to do welding repairs on the hairline cracks immediately (see [120]-[121] above).

359 The emanation of oil vapours from the oil jacket was a red flag indicating temperature and pressure issues within the oil jacket. Yet, the decision to perform welding repairs was taken almost immediately before any investigation into the root cause. Indeed, welding would not address the root problems which had caused the escape of oil vapours from the oil jacket to begin with. The fundamental issue as to why hairline cracks were appearing on the oil jacket was not considered. Chua XD did not even visit the Tuas Site workshop to physically observe the white smoke before coming to a decision on next steps – the decision was taken via WhatsApp.

360 In any event, no welding repairs were done until after the incident on 12 February 2021. The matter was also not under any investigation in the interim. Chua

⁷¹⁰ NE 30 September 2021, pp. 46:20-49:20 (Moe EIC).

XD tried to downplay the incident by contending that he subsequently discovered that what Moe had seen were not oil vapours escaping from hairline cracks but innocuous water vapour.⁷¹¹ But Chua XD's reasons do not add up.

361 First, Chua XD claimed that the white smoke could not have been oil vapours, as the smoke was white and not black.⁷¹² Chua XD premised this on the fact that the oil inside the oil jacket was black in colour.⁷¹³ Leaving aside the issue of *why* the oil was black (see [355] above), Chua XD's logic here is difficult to follow. In any event, Chua XD admitted at the Inquiry hearing that it was possible that the white smoke could have been oil vapours.⁷¹⁴

362 Second, Chua XD claimed that the water vapour was a result of fire clay from the top of the Mixer Machine dripping onto the hot oil jacket surface.⁷¹⁵ However, after being played the video taken by Moe on 8 January 2021 at the Inquiry hearing, Chua XD conceded that, contrary to his claim, no smoke (or water vapour, as alleged) could be seen coming from the fire clay material on the Mixer Machine.⁷¹⁶

⁷¹¹ SS-6 (Chua XD), [155].

⁷¹² SS-6 (Chua XD), [155].

⁷¹³ NE 24 September 2021, p. 76:4-7 (Chua XD EIC).

⁷¹⁴ NE 24 September 2021, p. 75:18-23 (Chua XD EIC).

⁷¹⁵ SS-6 (Chua XD), [155].

⁷¹⁶ NE 24 September 2021, pp. 77:13-78:11 (Chua XD EIC).

363 Third, Chua XD claimed that the water vapour was a result of water from loose gland packing at the sides of the Mixer Machine.⁷¹⁷ According to Chua XD, the issue resolved itself after he tightened the gland packing on a subsequent date.⁷¹⁸ This was contrary to Moe's witness statement where he explained that the white smoke was observed until after the fire on 12 February 2021 when welding repairs were done to the Mixer Machine.⁷¹⁹ At the Inquiry hearing, Moe stated for the first time that Chua XD had told him on 17 February 2021 that the issue of the white smoke had been resolved after the gland packing was tightened.⁷²⁰ However, these claims are not credible:

- (a) The video taken by Moe on 8 January 2021⁷²¹ shows the white smoke coming out only from the bottom corners of the oil jacket and does not show any water dripping from the gland packing onto the oil jacket;
- (b) If the white smoke had indeed been a result of dripping water or fire clay, Moe would have certainly noted so on 8 January 2021 itself; and

⁷¹⁷ SS-6 (Chua XD), [155].

⁷¹⁸ NE 24 September 2021, p. 73:11-21 (Chua XD EIC).

⁷¹⁹ SS-7 (Moe), [70].

⁷²⁰ NE 30 September 2021, pp. 50:13-51:18 (Moe EIC).

⁷²¹ S-159.

(c) Chua XD was unable to provide any details on when exactly he tightened the gland packing.⁷²² Although Moe says Chua XD did so on 17 February 2021, Chua's own account of what he did when he visited the Tuas Site workshop on 17 February 2021 omits any reference to tightening the gland packing.⁷²³

364 It is more likely that Chua XD and Moe were aware of the issue of oil vapours coming out from the oil jacket on 8 January 2021. White smoke was also seen in the video taken by Mehedi on 12 October 2020 of the hairline crack and leak on the front bottom left corner of the oil jacket (see [114] above).⁷²⁴ Both Moe and Chua XD had seen Mehedi's video⁷²⁵ and would have known that the white smoke was coming from inside the oil jacket. This explains why Moe and Chua XD were quick to pick the same remedy as in the 12 October 2020 incident – welding.

365 The reality is that Stars simply did not take any urgent steps to resolve the matter, let alone investigate the matter. As explained above, Moe's video on 8 January 2021 was shown to Dr Salim, and his opinion was that the white smoke could be aerosols formed either by condensation of oil vapours, or ejection of the oil directly via very small holes, likely due to pressure inside the oil jacket (see

⁷²² NE 24 September 2021, p. 84:1-10 (Chua XD EIC).

⁷²³ SS-6 (Chua XD), [205(e)].

⁷²⁴ S-158.

⁷²⁵ SS-7 (Moe), [59]; SS-6 (Chua XD), [150].

[230] above). If Stars had investigated the matter, they would have realised that pressure was building up within the oil jacket.

(e) *Boiling sounds from the oil jacket*

366 Chua XD explained that he heard oil boiling sounds from the oil jacket whenever the Mixer Machine was in operation during the production of fire clay.⁷²⁶ Other Stars workers have also reported hearing such boiling sounds (see [99] and [138] above). According to Jitu, he could hear the boiling sounds from the ground floor of the workshop where he was working.⁷²⁷ When Murugan and Chua XD heard the boiling sounds on 12 February 2021, the Mixer Machine had already been turned off for more than an hour (see [138]-[139] above).

367 If Chua XD had paid attention to the above-described phenomenon, and paused to consider what the boiling sounds indicated, he would have realised, as he acknowledged at the Inquiry hearing, that oil vapour and pressure were building up inside the closed oil jacket.⁷²⁸

⁷²⁶ SS-6 (Chua XD), [173].

⁷²⁷ NE 28 September 2021, p. 22:2-18 (Jitu EIC)

⁷²⁸ NE 24 September 2021, pp. 108:24-109:16 (Chua XD EIC).

(f) *Fire on 12 February 2021*

368 The incident on 12 February 2021 was a near-miss in that it was fortunate that casualties/injuries had not occurred. Viewed cumulatively with earlier red flags and the subsequent discovery of cracks on the Mixer Machine on 13 February, it would have become clear that a serious and urgent review of the Mixer Machine's condition and operating procedure was necessary.

369 Yet, Chua XD contrived to treat the fire on the Mixer Machine on 12 February 2021 as isolated from the cracks and oil stains found on the Mixer Machine (see [141] above). He purported to take the view that the oil in the oil jacket was not involved in the fire. This is inexplicable.

370 On 12 February 2021, Chua XD purportedly concluded that oil was not involved in the fire for two reasons, neither of which are sound:

(a) Chua XD's first reason was that he had not observed a dripping flame from the Mixer Machine (see [141] above). However, at the Inquiry hearing, Chua XD accepted that the lack of a dripping flame was not a reason to rule out an oil fire, especially if the oil stayed on the body of the Mixer Machine, as evidenced by the ensuing oil stains on the exterior of the oil jacket.⁷²⁹

⁷²⁹ NE 24 September 2021, pp. 94:13-96:14 (Chua XD EIC).

(b) Chua XD's second reason was that only the aluminium tape on the insulation on the Mixer Machine had caught fire (see [141] above). But there is no logical basis for thinking that the aluminium tape catching fire rules out an oil fire. It is equally possible that the burnt aluminium tape was a consequence of an oil fire.

371 In any event, it is clear that notwithstanding his purported views about a "tape" fire, Chua XD had not ruled out that oil was leaking from the oil jacket, as seen from his instructions for welding to be done on multiple locations on the bottom of the oil jacket.

372 Even if one were to ignore past red flags, a reasonable response to the fire on 12 February 2021 as a stand-alone incident would have been to call a safety time-out and conduct a fresh risk assessment of the Tuas Site workshop, including a thorough inspection of the Mixer Machine. This was a fire that halted production on 12 February 2021 and filled the workshop with smoke (see [130] above). It led to at least one Stars worker expressing fear for his safety (see [147]-[149] above). It was plainly a significant near-miss event. Instead, Chua XD did not even visit the Tuas Site workshop until after the in-house repairs by Nasim were completed days later (see [162] above).

373 The relevant Code of Practice on risk management (applicable at the material time) required Risk Assessment ("RA") entries to be reviewed upon any

accident, incident, near miss or dangerous occurrence.⁷³⁰ Yet, Chua XD did not initiate a review of the RA form in respect of the production at the Tuas Site workshop.⁷³¹ In fact, the RA had never been reviewed since its first preparation on 30 March 2020. Chua XD explained that he took some precautionary measures on the ground and gave practical advice to his workers.⁷³² However, what is clear is that Chua XD was keen to restart production at the Tuas Site workshop as soon as possible. On 15 February 2021 evening, he messaged in the Shield+ WhatsApp chat that he needed the welding repairs to finish the next day, and that they would start making fire clay again the day after next.⁷³³

374 Chua XD claimed that following the 12 February 2021 fire, he had given the Mixer Machine an “*ultimatum*”.⁷³⁴ Due to various problems with the Mixer Machine, he had decided that if there were any more problems with the Mixer Machine, he would stop using the Mixer Machine.⁷³⁵

⁷³⁰ “Code of Practice on Workplace Safety and Health Risk Management” published in 2015 (Second Revision) by the WSHC, [6.1.4].

⁷³¹ S-266; SS-6 (Chua XD), [207].

⁷³² SS-6 (Chua XD), [207].

⁷³³ SS-6 (Chua XD), [205(b)]-[205(c)].

⁷³⁴ NE 24 September 2021, p. 131:13-15 (Chua XD EIC).

⁷³⁵ NE 24 September 2021, pp. 131:13-132:23 (Chua XD EIC).

Examination of Chua XD by State Counsel

Q. I have -- at that point of time, right, I'm actually having the ultimatum of these existing mixer, that means, I have -- **I had enough of this mixer.**

Q. You had enough of it, you were fed up with it?

A. Yes.

Q. **So many problems occurring with it, right?**

A. **This is -- I'm just stating the facts, the truth.**

...

A. My thinking is **if I have any more problems coming up, I will change or stop using this -- this -- this mixer.** This is my thinking at that moment.

Q. Okay. So you're saying -- and I'm trying to quote your exact words: "If I have any more problems coming up, I will change or stop using this mixer." Correct?

A. Yes, your Honour.

Q. Actually, to change the mixer, you have to stop using it. **So can I just say your position at that point in time was, "If I have any more problems coming up, I'm going to stop using this mixer", correct?**

A. **Yes, your Honour.**

(emphasis added)

375 What the above exchange shows is that Chua XD was himself aware that the Mixer Machine was no longer reliable. Chua XD had seen and appreciated the

significance of this red flag. This was confirmed by the various measures he required in place in the event of another fire (eg, placing fire blankets and extra wet type fire extinguishers at the workshop).⁷³⁶ Having decided for himself that the Mixer Machine was no longer reliable, the only reasonable course of action would be to stop Stars' workers from using the Mixer Machine. Yet, Chua XD decided to give the Mixer Machine one more chance.

(g) *Cracks on the oil jacket*

376 Cracks were identified on the Mixer Machine on 28 September 2020 (see [100] above), 12 October 2020 (see [113] above), and 13 February 2020 following the fire on 12 February 2021 (see [153] above). These were obvious red flags. As explained above, Mr Shandro commented that the cracks were a result of pressure increases causing tensile stress (see [233] above). According to Dr Salim, such cracks were indicative of pressure within the oil jacket.⁷³⁷

377 Chua XD was made aware of the cracks:

- (a) As regards the 28 September 2020 crack, Chua XD simply failed to respond. Chua XD was notified about the crack by late September 2020⁷³⁸ but he did not investigate the matter or give any instructions until the crack

⁷³⁶ SS-6 (Chua XD), [207].

⁷³⁷ NE 5 October 2021, pp. 65:14-66:8 (Dr Salim EIC).

⁷³⁸ NE 27 September 2021, p. 158:3-6 (Chua XD EIC).

became bigger on 12 October 2020.⁷³⁹ Instead, Chua XD appears to have overlooked the crack altogether when he performed his maintenance check on the Mixer Machine for the month of October,⁷⁴⁰ and when he gave the workers instructions to use the Mixer Machine to make fire clay on 12 October 2020.⁷⁴¹ Chua XD accepted, in this regard, that it was very dangerous for the workers to have operated the Mixer Machine in such circumstances as it was a potential fire hazard.⁷⁴²

(b) When the same crack was observed to be bigger on 12 October 2020, Chua XD gave instructions to weld the crack (see [116] above). Similarly, Chua XD gave instructions to weld the cracks that were observed on 13 February 2021 (see [155] above). However, on neither occasion did Chua XD physically inspect the cracks or investigate as to their root cause before giving the instructions to weld.⁷⁴³

378 Moe was also made aware of the cracks, but he never personally investigated the matter. As regards the 28 September 2020/12 October 2020 crack, he limited his involvement to instructing Imam and Mehedi to have Nasim perform

⁷³⁹ NE 24 September 2021, p. 59:15-19 (Chua XD EIC).

⁷⁴⁰ S-245; NE 24 September 2021, p. 58:8-25 (Chua XD EIC).

⁷⁴¹ NE 24 September 2021, pp. 62:25-63:7 (Chua XD EIC).

⁷⁴² NE 24 September 2021, p. 63:8-16 (Chua XD EIC).

⁷⁴³ NE 24 September 2021, pp. 69:23-70:19; p. 119:8-14 (Chua XD EIC).

welding repairs (see [101]-[104]; [116] above),⁷⁴⁴ but never checked if the repairs had been performed. In relation to the 13 February 2021 cracks, Moe simply did not get involved and was content to let Chua XD handle the matter.

379 The presence of cracks should have caused serious concern to Stars. By 13 February 2021, it should have been clear that the previous attempt to repair the 28 September 2020/12 October 2020 crack was in vain. It was futile and foolhardy to undertake similar repairs without investigating the root cause of the cracks. If Stars had undertaken such an investigation, it would have realised that the pressure build-up within the oil jacket was the root cause and that welding was only a temporary solution.

(h) Small fire in the earlier part of the morning of 24 February 2021

380 The incident on the morning of 24 February 2021 was another near-miss event. This was the second fire involving the Mixer Machine in a span of about two weeks. According to Chua XD's "*ultimatum*" (see [374] above), he should have abandoned thought of further using the Mixer Machine and called a halt to fire clay production for that day. However, as it turned out, Chua XD was not prepared to carry out his "*ultimatum*". This was a serious failure.

⁷⁴⁴ NE 30 September 2021, pp. 69:9-71:11 (Moe EIC).

381 We submit that, following the small fire on the morning of 24 February 2021, the evidence shows that Chua XD told Marimuthu to change the damaged Heater No. 2 (see [178]-[181] above). Chua XD contended that he only meant for Marimuthu to take out the damaged heater and wait for Chua XD to arrive at the workshop.⁷⁴⁵ However, according to Moe, he understood from Marimuthu's messages to him at that time that Chua XD had told Marimuthu to replace the damaged heater.⁷⁴⁶

382 Chua XD insisted that he himself had no intention to replace the damaged heater when he arrived at the workshop; his only intention was to remove the damaged heater.⁷⁴⁷ Chua XD's claim that his intention was only to remove the "threat" of the damaged heater⁷⁴⁸ is not credible. Marimuthu had already informed Chua XD that the Mixer Machine had been stopped and that the cables had been disconnected.⁷⁴⁹ Chua's XD own position is that if the Mixer Machine had remained switched off, there would be no risk of an explosion – "*there's no power, no movement and you see everything is in off mode, so I don't think it will explode*".⁷⁵⁰ Given this, there was simply no reason for Chua XD to have instructed Marimuthu to remove the damaged heater for any purported safety reasons. In line with Chua

⁷⁴⁵ NE 27 September 2021, pp. 42:11-43:14 (Chua XD Re-ex).

⁷⁴⁶ NE 30 September 2021, p. 81:4-19 (Moe EIC).

⁷⁴⁷ NE 27 September 2021, p. 44:18-23 (Chua XD Re-ex).

⁷⁴⁸ NE 27 September 2021, p. 46:14-22 (Chua XD Re-ex).

⁷⁴⁹ SS-6 (Chua XD), [216].

⁷⁵⁰ NE 27 September 2021, p. 66:14-24 (Chua XD XX).

XD's "*ultimatum*" (see [374] above), Chua XD should have simply told the workers to get off the Platform and leave the Mixer Machine alone. But he did not do so.

383 Instead, the more likely explanation is that Chua XD intended to replace the damaged heater, and see if the Mixer Machine could work and production could carry on. This had been done before on 8 August 2020 when Imam changed the damaged Heater No. 1 (see [87] above).

384 Even if (which is denied) Chua XD had not wanted Marimuthu to change the heater before Chua XD arrived at the Tuas Site workshop, Chua XD had, minimally, intended to replace the damaged heater and carry on with fire clay production and had communicated the same to Marimuthu. Marimuthu would have accordingly felt pressure to get the Mixer Machine up and running again as soon as possible, so that the workers could complete making the required rolls of fire wrap by the end of the work day.

385 In this regard, Mehedi gave evidence that if fire clay production had stopped abruptly for any reason, the workers would not have been able to complete the day's target of 32 rolls of fire clay set by Chua XD (see [69] above).⁷⁵¹ Marimuthu would have felt pressure because by February 2021, Stars had more orders for fire wrap to

⁷⁵¹ NE 21 September 2021, p. 99:16-22 (Mehedi Re-ex).

meet.⁷⁵² He was the type of worker who would push to meet targets.⁷⁵³ This explained why Marimuthu may have attempted his own fix with green tape around the damaged wiring of Heater No. 2 (see [184] above) and why the Mixer Machine was turned on again on 24 February 2021 (see [182] above). Such an in-house fix would also have been in keeping with Stars' prevailing practice of performing in-house repairs on the Mixer Machine (see [117] and [150]-[160] above).

386 Moe was aware that Marimuthu had attempted his own fix with green tape around the damaged heater's wires. Moe received a photograph of the fix from Marimuthu (see [187] above). Moe did not express any surprise or query Marimuthu on what he was doing. Moe claimed that he assumed Marimuthu and Shohel was checking the "*continuity*" of the heater cables and that by this, Moe envisaged that they were checking on the condition of the heater wires after they had been taped up.⁷⁵⁴

387 Moe contends that he did not think that Marimuthu was checking whether the damaged heater could still work.⁷⁵⁵ This is despite the fact that the wires with the green tape were connected to the damaged heater.⁷⁵⁶ There would have been no

⁷⁵² SS-6 (Chua XD), [93]; NE 24 September 2021, pp. 141:23-142:5 (Chua XD EIC); SS-7 (Moe), [108].

⁷⁵³ NE 27 September 2021, p. 142:6-19 (Chua XD EIC).

⁷⁵⁴ NE 30 September 2021, p. 85:3-23 (Moe EIC).

⁷⁵⁵ NE 30 September 2021, p. 85:24-86:1 (Moe EIC).

⁷⁵⁶ NE 30 September 2021, p. 86:13-17 (Moe EIC).

reason for the workers to tape up the damaged heater and/or to test its cables unless they were intending to use the damaged heater, and Moe must have clearly understood this.

388 Further, Moe claimed that his knowledge of needing to check the heater cables came from the 8 August 2020 incident when Imam changed the damaged Heater No. 1.⁷⁵⁷ However, on 8 August 2020, Imam had done his checks, including a “continuity” check, on the new heater after the damaged heater had been replaced (see [87] above). When it was put to Moe that he knew from his experience that “continuity” checks were only done on a heater intended for use, he evaded the obvious conclusion:⁷⁵⁸

Examination of Moe by State Counsel

Q. Mr Moe, if you had really thought back to 8 August you would know that checking continuity comes only after you replace the heater unless you intend to use precisely the heater you’re checking the continuity of, agree?

A. I’m not sure.

389 Accordingly, Moe’s account that he was unaware that Marimuthu was checking whether the damaged heater could still work is not believable. Instead, the

⁷⁵⁷ NE 30 September 2021, pp. 127:18-128:6 (Moe XX).

⁷⁵⁸ NE 30 September 2021, p. 136:12-17 (Moe Re-ex).

more likely explanation is that Moe knew that Marimuthu was checking whether the damaged heater could still work. Moe would have felt pressure to ensure that production could carry on at the workshop that day to fulfil the orders for fire wrap. Handling sales for fire wrap and ensuring that production ran smoothly were precisely Moe's duties.⁷⁵⁹ Hence, Moe was content to let Marimuthu try his own fix with green tape around the damaged heaters wires. Moe was plainly ambivalent as to the precise steps Marimuthu and Shohel were going to take, and did not consider their safety when leaving them to their own devices.

390 Given the earlier fire involving the heater, Moe ought to have known that any further attempt to use the same heater carried safety risks. In fact, Moe's own position at the Inquiry hearing was that he had thought at that time that the workers should have stopped using the Mixer Machine after the small fire on 24 February 2021.⁷⁶⁰

Examination of Moe by State Counsel

Q. Do you agree that the safe thing to do on 24 February 2021 morning, especially after this fire that had occurred early in the morning, is to just stop using the mixer machine altogether, decommission?

A. I followed my boss' instructions to change the heater.

⁷⁵⁹ SS-7 (Moe), [32(a)] and [32(e)].

⁷⁶⁰ NE 30 September 2021, pp. 101:11-102:1 (Moe EIC)

Q. That is not quite my question, Mr Moe. I am asking for your own view. **Did you think, on 24 February 2021 morning, especially given the fire that had already occurred early in the morning, that the workers just shouldn't be using the mixer machine anymore?**

A. **Yes, yes, should not be using. Yes.**

Q. **You thought that at that time?**

A. (In English) **Yes. Yes.**

(emphasis added)

391 Yet, Moe did nothing to stop Marimuthu and Shohel on the morning of 24 February 2021. In fact, having seen the photograph from Marimuthu, Moe asked Marimuthu for an update (see [188] above) although by that time, the Accident had already occurred – Moe was unaware that the safety risk had eventuated.

392 This explains why Moe chose to delete the WhatsApp messages containing the photograph that Marimuthu sent him and his request to Marimuthu for an update (see [189] above). Following the Accident, it would have dawned on Moe that he should not have allowed Marimuthu and Shohel to attempt to use the damaged heater when it was unsafe to do so. As the Production Engineer and someone who knew what Marimuthu and Shohel were doing, it would have behoved Moe to stop them. Hence, Moe felt compelled to get rid of the evidence that implicated him.

3. Stars failed to consult the manufacturer or a competent person before performing in-house repairs on the Mixer Machine

393 To deal with the cracks observed on the Mixer Machine, Stars resorted to having Nasim perform in-house welding repairs on the Mixer Machine following each of the incidents on 12 October 2020 and 12 February 2021 (see [117] and [150] above).

394 Nasim is a welder at Stars and has the relevant certification to perform welding works.⁷⁶¹ However, Matcor explained that the resistance of welds overall would be affected by having the repair welds over the original welding and that the repair welding done by Stars were of poor quality (see [258]-[259] above). Ultimately, as explained above at [261], poor welding repairs weakened the strength of the welds on the Mixer Machine which in turn contributed to the eventual rupture of the Mixer Machine.

395 The guidance on machinery maintenance and repair is clear: machines must be maintained and repaired according to manufacturer's specifications or, in the absence of such specifications, in accordance with a competent person's recommendations.⁷⁶² However, Chua XD was content to proceed with welding repairs on the Mixer Machine without consulting Laizhou Keda. As regards the

⁷⁶¹ SS-4 (Nasim), [2] and [7].

⁷⁶² "Workplace Safety and Health Guidelines, Safe Use of Machinery" published in 2014 by the Workplace Safety and Health Council and which was applicable at the material time.

incident on 12 October 2020, Chua XD did not contact Laizhou Keda (see [116] above).⁷⁶³ As for the incident on 12 February 2021, Chua XD had contacted Laizhou Keda but only for the limited purpose of obtaining a quote for a new mixer machine.⁷⁶⁴ Chua XD was also well aware that by performing in-house welding repairs, he had voided the terms of the warranty provided by Laizhou Keda.⁷⁶⁵

396 Stars also did not obtain any independent advice regarding the appropriate repairs from a competent person.

397 If Stars had consulted Laizhou Keda or obtained independent advice, Stars would not have had to resort to in-house welding repairs which ultimately weakened the strength of the welds on the Mixer Machine. Stars may have received advice that the Mixer Machine was no longer fit for use or it may have experienced downtime waiting for the Mixer Machine to be professionally repaired and certified fit for use. Either scenario would have been a safer course of action and would have prevented the loss of lives.

398 Another repair/modification that Stars performed on the Mixer Machine without consultation was the in-house installation of insulation over the surface of the oil jacket (see [124] and [163] above). Chua XD accepted that this had the effect

⁷⁶³ SS-6 (Chua XD), [152].

⁷⁶⁴ SS-6 (Chua XD), [208]-[209].

⁷⁶⁵ SS-6 (Chua XD), [208].

of trapping heat within the oil jacket⁷⁶⁶ and Dr Salim opined that the trapped heat would increase the temperature of the oil inside the jacket.⁷⁶⁷ This would in turn have had an impact on the overall pressure build-up within the oil jacket which led to the Accident.

4. *Stars failed to ensure that those working at the Tuas Site had adequate instruction, information, training and supervision*

399 Stars had also failed to ensure that those working at the Tuas Site had adequate instruction, information, training and supervision.

400 It is recognised that the Stars workers played different roles in fire wrap production, hence they would not have been given equivalent training for each of their roles. However, it is evident that the instruction, information, training and supervision for each Stars worker was insufficient for the roles they played within the Tuas Site workshop.

401 For the operation of the Mixer Machine, it was claimed that Chua and Moe personally trained the workers in how the Mixer Machine was to be operated. However, the training was patchy at best. Chua had conducted training on the Mixer Machine for Imam and Moe without an adequate understanding of how the Mixer

⁷⁶⁶ NE 27 September 2021, p. 182:13-21 (Chua XD, questions from IC).

⁷⁶⁷ NE 5 October 2021, pp. 41:19-42:1 (Dr Salim EIC).

Machine worked, and had done so without even reading the User Guide on 12 June 2020 itself.⁷⁶⁸ Evidence of the alleged training conducted, in the form of videos recorded on 12 June 2020,⁷⁶⁹ revealed no actual instructions on how the Mixer Machine was to be operated.

402 This resulted in the workers operating the Mixer Machine having little knowledge on the actual operation of the Mixer Machine. Moe, who was the production engineer in charge of the Tuas Site workshop, and had supposedly trained Marimuthu on how to use Mixer Machine,⁷⁷⁰ had merely taught Marimuthu the processes involved, without teaching any of the checks required (see [62(c)] above).⁷⁷¹ Moe did not even know how much oil needed to be in the oil jacket or why the oil level must be checked, and had left the matters relating to the Mixer Machine to Chua XD.⁷⁷²

403 The same could be said for Imam, who subsequently taught Mehedi how to operate the Mixer Machine (see [62(a)] above). He was merely taught the steps on how to operate the Mixer Machine by Chua XD, without any reference to the User Guide, and was not taught anything on the maintenance of the Mixer Machine.⁷⁷³

⁷⁶⁸ NE 23 September 2021, p. 131 (Chua XD EIC).

⁷⁶⁹ S-149 and S-150.

⁷⁷⁰ NE 30 September 2021, pp. 7:24-8:5 (Moe EIC).

⁷⁷¹ NE 30 September 2021, pp. 8:6-9:25 (Moe EIC).

⁷⁷² NE 30 September 2021, pp. 9:1-10:1 (Moe EIC).

⁷⁷³ SS-2 (Imam), [27]-[30].

By the time Imam trained Mehedi on the use of the Mixer Machine, the only information conveyed was how to open the cover/lid of the Mixer Machine, how to start and stop the mixing function, and how to switch on and off the heaters using the control panel.⁷⁷⁴ While Imam and Mehedi were of the opinion that such training was adequate, because they were able to operate the Mixer Machine for their work,⁷⁷⁵ the training, instruction, supervision and instruction was objectively insufficient for the safe operation of the Mixer Machine.

404 There was also inadequate instruction and training for the workers in charge of other aspects of the production process. Moe claimed that he had trained the workers personally when they first started work at the Tuas Site, and had referred to the RA and SWP documents when doing so.⁷⁷⁶ This was not supported by the evidence of the Stars workers, who informed that they were shown what to do by the other workers already working at the Tuas Site.⁷⁷⁷ Even on Moe's account, the parts of the SWP referred to in training the workers only related to the manufacturing steps for the fire wrap, and did not refer to any safety aspects in

⁷⁷⁴ SS-3 (Mehedi), [30].

⁷⁷⁵ NE 20 September 2021, p. 136:1-8 (Imam XX), NE 21 September 2021, p. 82:6-25 (Mehedi XX).

⁷⁷⁶ SS-7 (Moe), [110] and [137].

⁷⁷⁷ SS-11 (Rahad), [22]; SS-12 (Lizon), [43]; NE 28 September 2021, p. 29:1-5 (Jitu EIC).

relation to the work at the Tuas Site.⁷⁷⁸ Chua XD's assumption that Moe had adequately briefed the workers on the RA⁷⁷⁹ was therefore misplaced.

405 Stars has attempted to portray that the general briefings by Shibu would have been applicable to the work at the Tuas Site. However, the briefings by Shibu generally related to the work at the project sites.⁷⁸⁰ Shibu did not even have any knowledge of the processes at the Tuas Site, as he had not been to the Tuas Site before the Accident.⁷⁸¹ While there was a briefing given on hazardous materials on 16 June 2019, Shibu explained that it related to the oil used when threads were cut on pipes, and to paints used, and did not relate to any of the processes at the Tuas Site workshop, which was not in operation then.⁷⁸² There was also no reason for the workers to think that the requirements for attire at the project sites, which were construction sites, would be equally applicable to the Tuas Site, which was in effect a production workshop.

406 This was compounded by there being no safety supervisor appointed at the Tuas Site. Chua XD confirmed that there was no specific appointment for a safety supervisor at the Tuas Site, and he could not recall if he had told Moe, Imam or

⁷⁷⁸ SS-7 (Moe), [137]; S-264 – see [3.4]-[3.8] on what Moe supposedly briefed for operation of the Mixer Machine, and [3.10]-[3.18] for what was supposedly briefed by Moe for fire wrap production.

⁷⁷⁹ SS-6 (Chua XD), [112].

⁷⁸⁰ SS-15 (Shibu), [6(c)].

⁷⁸¹ SS-15 (Shibu), [8] and [10].

⁷⁸² NE 1 October 2021, pp. 30:7-32:8 (Shibu EIC).

Marimuthu that they were responsible for safety issues at the Tuas Site.⁷⁸³ He had therefore assumed that these supervisors would escalate any safety issues to him. This assumption, however, was not reasonable – Imam did not see himself as responsible for safety issues,⁷⁸⁴ and Moe purported not to see safety as part of his portfolio at the Tuas Site workshop.⁷⁸⁵ The workers were therefore not supervised for safety aspects when working at the Tuas Site.

407 Lastly, none of the workers were told anything about the risks involved when handling potato starch, which is a combustible dust. While the MOM Circular on the Hazards and Controls of Combustible Dusts (the “**Combustible Dust Circular**”) requires training and refresher courses to be provided on combustible dust hazards and its controls, and to communicate clearly the combustible dust hazards and its physical properties, safe handling practices and precautions to be taken,⁷⁸⁶ there was no evidence that the workers at the Tuas Site were told anything about the hazards involved when dealing with potato starch at the Tuas Site.

408 The end result was that the workers at the Tuas Site were not given sufficient training, supervision, instruction and information on the processes they were to perform, the risks and hazards involved on the Tuas Site, and the precautions they

⁷⁸³ SS-6 (Chua XD), [116].

⁷⁸⁴ SS-2 (Imam), [41].

⁷⁸⁵ SS-7 (Moe), [32].

⁷⁸⁶ S-233, p. 3.

had to take. It was reasonably practicable for Stars to have taken additional steps to ensure these were done: assumptions on Chua's part that his subordinates would take care of these aspects, when his subordinates were not even told they were in charge, were clearly unreasonable.

5. *Stars failed to take precautions for the use of potato starch powder at the Tuas Site workshop*

409 It is clear that the RA form in respect of the production at the Tuas Site workshop⁷⁸⁷ did not even identify potato starch powder as a potential combustible dust hazard,⁷⁸⁸ let alone prescribe any safety measures to address the risks associated with this hazard. Stars had failed to take precautions for the use of potato starch powder at the Tuas Site, in failing to take reasonably practicable steps to prevent a dust explosion on site in the following areas:

- (a) enclosure of the Tuas Site workshop and taking reasonable steps to restrict the spread and effect of a dust explosion should it occur;
- (b) dust control;
- (c) exclusion/enclosure of possible sources of ignition;

⁷⁸⁷ S-266.

⁷⁸⁸ NE 30 September 2021, pp. 20:2-21:19 (Moe EIC).

- (d) use of suitable explosion-proof equipment; and
- (e) use of suitable PPE on site.

410 No steps had been taken to enclose the Tuas Site workshop, or to restrict the spread and reach of a dust explosion should it occur. The Tuas Site workshop was entirely open to the neighbouring units and the other levels, where the raw materials were kept and the Stars workers were staying in, such that the potato starch used at the Tuas Site could have flown to the other areas. There were no signs of any vents to redirect energy from an explosion to a safe location, or other equally effective measures at the Tuas Site to restrict the spread and effect of a dust explosion should it occur – the Tuas Site workshop was one contiguous working area. The placement of the Mixer Machine on the Platform was not done to restrict the spread and effect of a dust explosion with potato starch should such an explosion occur: as explained by Chua XD, it was done so that it would be easier to transfer the heavy fire clay produced from the Mixer Machine to the extruder machine beneath it.⁷⁸⁹

411 For dust control, the ventilation measures taken by Stars (see [63] above) did not satisfy what was required in the Combustible Dust Circular.⁷⁹⁰ Chua XD was aware of this Circular, having read it sometime in 2019, and was aware that it

⁷⁸⁹ SS-6 (Chua XD),[42].

⁷⁹⁰ S-233.

applied to fire wrap production at the Tuas Site workshop.⁷⁹¹ However, the available measures were either not used or not working for significant periods or ineffective for dust control (*eg*, the exhaust vent, which, as explained above at [63], was not placed above the Mixer Machine and served only to facilitate general ventilation at the workshop instead of effectively sucking up dust); or served to disperse the dust, including the potato starch around the Tuas Site workshop instead (*eg*, sweeping; fans which, as explained above at [63], blew in the direction of the Platform and the assembly tables and would serve to spread dust there; blowing dust off tables with compressed air guns).

412 Possible sources of ignition were not enclosed or excluded within the Tuas Site workshop. While Chua XD has attempted to explain that gas torches were only used around the production tables for the sealing of the fire wrap, and “*no potato starch*” was present there,⁷⁹² this was clearly untenable, as the workers have explained that the entire working area was dusty (see [64] above), and the production tables must have been the same to necessitate the use of the compressed air gun. Likewise, the tipping of bags of potato starch directly into the mixing chamber of the Mixer Machine that was placed on a raised platform, would have resulted in powders and dust flying up,⁷⁹³ and the Mixer Machine itself had multiple

⁷⁹¹ SS-6 (Chua XD), [105].

⁷⁹² SS-6 (Chua XD), [87].

⁷⁹³ NE 21 September 2021, pp. 69:20-70:12 (Mehedi EIC).

heated surfaces. There was therefore airborne potato starch in the entire Tuas Site workshop, within which there were multiple possible sources of ignition.

413 There were no steps taken to use explosion-proof equipment at the Tuas Site. The Mixer Machine itself was not explosion-proof.⁷⁹⁴ Neither were the lights, power switches, fans or other electrical equipment.⁷⁹⁵ Chua XD had explained that he took no steps to use explosion-proof equipment as he had determined that the quantity of potato starch was not high, and that the surroundings were “*intrinsically safe*”.⁷⁹⁶ However, bearing in mind that a layer of only 0.8mm of combustible dust was required to create a dust explosion or flash fire hazard,⁷⁹⁷ Stars’ failure to utilise any explosion-proof equipment within the Tuas Site was clearly not reasonable.

414 Lastly, Stars did not take measures to ensure that the workers on site wore suitable PPE, such as fire retardant clothing or static dissipative safety shoes, as was suggested in the Combustible Dust Circular.⁷⁹⁸ Chua XD did not issue fire retardant clothing to any of the Stars workers, and had only asked Marimuthu to put on a welding jacket when operating the Mixer Machine after the 12 February 2021 fire, to calm Marimuthu down.⁷⁹⁹ The workers who joined the Tuas Site workshop after

⁷⁹⁴ SS-6 (Chua XD), [48].

⁷⁹⁵ SS-6 (Chua XD), [107].

⁷⁹⁶ SS-6 (Chua XD), [107].

⁷⁹⁷ S-283 (Dr Salim’s Report), p. 46:11-13.

⁷⁹⁸ S-233, p. 3.

⁷⁹⁹ NE 24 September 2021, pp. 138:4-139:11 (Chua XD EIC).

Chinese New Year were not issued respirators, even when they asked for one.⁸⁰⁰ Neither were protective eyeglasses or chemical safety goggles, which were suggested in the safety data sheet for bentonite clay received by Stars on 23 October 2020,⁸⁰¹ made mandatory in the Tuas Site workshop.

415 While it was claimed that safety shoes were required on site, there were no steps taken when it was clear that Stars workers were wearing slippers during fire wrap production. Chua XD did not take any steps in this regard after seeing the videos on 12 February 2021 that some of the workers were wearing slippers at the Tuas Site, as he claimed that he depended on Marimuthu to remind the workers of such matters.⁸⁰² Rahad had also stated that Chua XD and Moe had seen some of the workers and him wear shorts and slippers at the Tuas Site workshop, but did not say anything about it.⁸⁰³

416 Stars evidently failed to take reasonable precautions for the use of potato starch powder at the Tuas Site workshop. The measures stated above were reasonably practicable, being specifically addressed in the Combustible Dust Circular or required in regulation 26 of the Workplace Safety and Health (General Provisions) Regulations (“**WSH (GP) Regs**”). Following the fire on 12 February

⁸⁰⁰ NE 24 September 2021, pp. 138:4-139:11 (Chua XD EIC).

⁸⁰¹ SS-6 (Chua XD), [109].

⁸⁰² SS-6 (Chua XD), [191].

⁸⁰³ SS-11 (Rahad), [60].

2021, Stars should have become acutely aware of the risk of a combustible dust explosion in the workshop. Yet, no special measures were taken to mitigate the risk. This contributed to the Accident, in terms of the availability of potato starch powder for combustion, and the spread of flash fires beyond Stars to the neighbouring Alif-E unit.

417 Having explored the causes, both technical and underlying, that led to the Accident, we now go on to consider TOR E on the potential offences disclosed.

V. TOR E: POTENTIAL OFFENCES DISCLOSED

418 Section 26(6) of the WSHA states:

“If the District Judge [appointed to the IC] is of the opinion that criminal proceedings ought to be instituted against any person in connection with the accident... he shall also forward a copy of the [IC’s] report to the Public Prosecutor.”

419 The IC’s TOR E mirrors Section 26(6) above. Hence, although the discretion to bring criminal proceedings as a result of the Accident lies with the Public Prosecutor, TOR E (as statutorily envisaged) requires the learned IC Chairman to consider whether any such criminal proceedings ought to be instituted. In this regard, the IC had directed that State Counsel assist by highlighting in these written submissions the possible criminal proceedings that may arise from the

Accident.⁸⁰⁴ Accordingly, we set out in this Section our preliminary views on the potential offences disclosed for the learned IC Chairman's consideration.

420 We clarify at the outset, that our views in this Section are subject to the following provisos:

(a) First, our views on potential offences disclosed are based purely on the facts and evidence adduced over the course of the Inquiry;

(b) Second, our views relate only to potential offences arising from matters directly related to the Accident itself;⁸⁰⁵

(c) Third, even in respect of matters directly related to the Accident, our views, in our capacity as State Counsel in this Inquiry, on potential offences are not intended to be definitive or exhaustive; and

(d) Fourth, there are significant overlaps in the elements of the possible offences disclosed, such that it would be a matter of prosecutorial discretion on the most appropriate offence(s) to prefer against each identified party.

⁸⁰⁴ NE 16 November 2021, p. 146:11-25 (Housekeeping).

⁸⁰⁵ Purely by way of illustration, we have not considered the legality or regulatory compliance of, for instance, the actions of building the raised Platform or the workers working at the workshop during the Circuit Breaker.

A. Stars is potentially liable under section 11 and/or 12 of the WSHA

421 Stars is potentially liable under section 11 (as occupier) and/or section 12(1)-(2) (as employer) of the WSHA for failing to take, so far as is reasonably practicable, such measures as are necessary to ensure the safety and health of the relevant persons/workers.

422 Section 11 of the WSHA provides:

Duty of occupier of workplace

11. It shall be the duty of every **occupier** of any workplace to take, **so far as is reasonably practicable**, such measures to ensure that —

- (a) the **workplace**;
- (b) all means of access to or egress from the workplace;
and
- (c) any **machinery, equipment, plant, article or substance kept on the workplace**,

are **safe and without risks to health to every person** within those premises, whether or not the person is at work or is an employee of the occupier.

(emphasis added)

423 The relevant parts of section 12 of the WSHA provide:

Duties of employers

- 12(1) It shall be the duty of every **employer** to take, **so far as is reasonably practicable**, such measures as are necessary to ensure the **safety and health** of his employees at work.
- (2) It shall be the duty of every **employer** to take, **so far as is reasonably practicable**, such measures as are necessary to ensure the **safety and health of persons (not being his employees) who may be affected by any undertaking carried on by him in the workplace**.
- (3) For the purposes of subsection (1), the measures necessary to ensure the safety and health of persons at work include —
- (a) providing and maintaining for those persons **a work environment which is safe, without risk to health**, and adequate as regards facilities and arrangements for their welfare at work;
 - (b) ensuring that adequate safety measures are taken in respect of any **machinery, equipment, plant, article or process** used by those persons;
 - (c) ensuring that those persons are not exposed to hazards arising out of the arrangement, disposal, manipulation, organisation, processing, storage, transport, working or use of things —
 - (i) in their workplace; or
 - (ii) near their workplace and under the control of the employer;

- (d) developing and implementing procedures for dealing with emergencies that may arise while those persons are at work; and
- (e) ensuring that those persons at work have adequate instruction, information, training and supervision as is necessary for them to perform their work.

(emphasis added)

424 As Stars is both occupier and employer in relation to the workplace at the Tuas Site workshop, both provisions are relevant.

425 An assessment under section 11 / section 12(1)-(2) of the WSHA requires a consideration of:

- (a) Whether there were foreseeable risks to safety and health arising from the operations at the Tuas Site workshop,⁸⁰⁶ and
- (b) If yes, whether there was a failure to take, so far as was reasonably practicable, such measures as were necessary to ensure the safety and health of the relevant persons/workers against the reasonably foreseeable risks.

⁸⁰⁶ Whilst reasonable foreseeability of a risk is not stated explicitly as an element in the duty of safety in section 11/ section 12 of the WSHA, English case law makes clear that the duty is to guard against reasonably foreseeable risks (*Baker v Quantum Clothing Group Ltd* [2011] 4 All ER 223 at [68], per Lord Mance; *R v Tangerine Confectionery Ltd* [2011] EWCA Crim 2015 at [36]). Our local courts also consider reasonable foreseeability of the risk when considering the reasonable practicability of taking measures (*Public Prosecutor v Underwater Contractors Private Limited and another* [2020] SGDC 299 at [195]).

426 In our view, the following risks to safety and health arising from the operations at the Tuas Site workshop were reasonably foreseeable:

(a) The risk of a fire or other accident involving the Mixer Machine at the workshop: The risk was objectively foreseeable in the light of all the red flags and near misses that had surfaced in relation to the Mixer Machine, including two prior fires involving the Mixer Machine (see [349]-[391] above). Additionally:

(i) At the very least, following the fire on 12 February 2021, Chua XD subjectively appreciated the risk of continuing to use the Mixer Machine; and

(ii) At the very least, following the small fire on 24 February 2021 morning, Moe subjectively appreciated the risk of continuing to use the Mixer Machine.

(b) The risk of a fire involving potato starch powder at the workshop: Insofar as there was a risk of a fire at the workshop (see [426(a)] above) which would be an obvious ignition source, there was an objectively foreseeable corresponding risk of a fire involving potato starch powder. Chua XD was aware that potato starch powder was a combustible dust,⁸⁰⁷

⁸⁰⁷ SS-6 (Chua XD), [105].

and he was aware of the hazards posed by combustible dust. He had read the Combustible Dust Circular and was aware that it applied to fire wrap production at the Tuas Site (see [411] above).

427 We further consider that Stars failed to take, so far as was reasonably practicable, such measures as were necessary to ensure the safety and health of the relevant persons/workers against the abovementioned reasonably foreseeable risks:

(a) As regards risk of a fire or other accident involving the Mixer Machine:

(i) Stars could have ensured the safe operation of Mixer Machine if it had used sufficient oil in the oil jacket, monitored the temperature of the oil and used the Mixer Machine as an open system as intended (see [311]-[348] above). It is undisputed that it would have been simple and uncostly for Stars to take these steps.

(ii) Moreover, following the fire on 12 February 2021, the safest course would have been to stop using the Mixer Machine until it was professionally inspected, and if possible, repaired and certified fit for use. Stars did not even entertain this thought, and chose to perform in-house welding repairs instead.

(iii) At the very latest, by the time of the small fire on 24 February 2021, all the workers should have been instructed to stay clear of the Mixer Machine. No such instructions were given. Instead, the workers were given the impression that the damaged heater could be replaced and that use of the Mixer Machine would continue.

(b) As regards risk of a fire involving combustible dust, Stars failed to take several reasonably practicable steps as set out in the Combustible Dust Circular (see [409]-[416] above).

B. Stars is potentially liable under section 17(4) of the WSHA

428 Stars is potentially liable under section 17(4)(a) of the WSHA (as owner of the Mixer Machine) for failing to ensure, so far as is reasonably practicable, that the Mixer Machine was maintained in a safe condition.

429 Section 17(4) of the WSHA provides:

Where any machinery moved by mechanical power is used in any workplace, then notwithstanding anything in this Act, it shall be the **duty of the owner of the machinery to ensure —**

(a) **so far as is reasonably practicable, that the machinery is maintained in a safe condition; and**

- (b) that the precautions (if any) to be taken for the safe use of the machinery and the health hazards (if any) associated with the machinery are available to any person using the machinery.

(emphasis added)

430 As Stars is the owner of the Mixer Machine, Stars' failure to adopt the reasonably practicable measures discussed at [427(a)] above (in the context of the risk of a fire or other accident involving the Mixer Machine) also apply in the context of section 17(4)(a) of the WSHA.

C. Chua XD is potentially liable under section 48(1) of the WSHA

431 Chua XD is potentially liable under section 48(1) of the WSHA (as Stars' sole director) for the offences committed by Stars as outlined above at [421]-[430].

432 Section 48(1) of the WSHA provides:

Where an offence under this Act has been committed by a body corporate, **an officer of the body corporate shall be guilty of the offence and shall be liable** to be proceeded against and punished accordingly unless he proves that —

- (a) the offence was committed **without his consent or connivance**; and

- (b) he had **exercised all such diligence to prevent the commission of the offence** as he ought to have exercised having regard to the nature of his functions in that capacity and to all the circumstances.

(emphasis added)

433 It is undisputed that Chua XD is overall in charge at Stars.⁸⁰⁸ It is also clear that the workers at the Tuas Site workshop and Moe reported to, and took instructions from, Chua XD. Chua XD made decisions on matters which go to the heart of the offences potentially committed by Stars, such as:

- (a) How much oil to purchase and use in the oil jacket;
- (b) Whether to measure the temperature of the oil in the oil jacket;
- (c) Whether to use the Mixer Machine as a closed system;
- (d) Whether to measure the pressure inside the oil jacket;
- (e) Whether to perform welding repairs on the Mixer Machine;
- (f) Whether to continue using the Mixer Machine; and

⁸⁰⁸ SS-6 (Chua XD), [16].

(g) What precautions to take for the use of potato starch powder at the Tuas Site workshop.

434 In the circumstances, Stars' offences were committed at least with Chua XD's consent.⁸⁰⁹ He was also the "boss" behind Stars' failure to take reasonable steps to ensure the workers' safety and cannot be said to have exercised any diligence to prevent such failure/offences.

D. Moe is potentially liable under section 15(3A) of the WSHA

435 Moe is potentially liable under section 15(3A) of the WSHA (as a person at work) for doing a negligent act which endangers the safety or health of others.

436 Section 15(3A) of the WSHA provides:

Any person at work who, without reasonable cause, does any negligent act which endangers the safety or health of himself or others shall be guilty of an offence and shall be liable upon conviction to a fine not exceeding \$30,000 or to imprisonment for a term not exceeding 2 years or to both.

⁸⁰⁹ In *AG's Reference* (No 1 of 1995) [1996] 4 All ER 21 at 27, the English Court of Appeal held that to prove consent, it must be shown that the accused person "[knew] the material facts which constitute the offence by the body corporate and ... [had] agreed to its conduct of its business on the basis of those facts".

437 The test for negligence is objective and involves a consideration of whether a reasonable person in the same circumstances would have been aware of the likelihood of damage or injury to others.⁸¹⁰

438 In this regard, focussing alone on Moe’s actions after the small fire involving Heater No. 2 on 24 February 2021 (see [386]-[392] above), Moe’s conduct was plainly negligent. A reasonable person would have been aware that any further attempt to use the same heater carried a likelihood of damage or injury to others.

439 Instead, Moe failed to stop Marimuthu and Shohel from attempting to use the same heater on 24 February 2021. He was content to let Marimuthu try his own fix with green tape around the damaged heaters wires. There is no reasonable cause for Moe’s failure. Even if Moe thought that Marimuthu and Shohel were acting on Chua XD’s instructions, this would not constitute reasonable cause. As stated by the High Court in *Nurun Novi* at [58]:

*“Parliament intended to effect a “cultural change” by expanding the liability framework to render even rank-and-file workers responsible for unsafe work practices. **This responsibility is not***

⁸¹⁰ *Nurun Novi Saydur Rahman v Public Prosecutor* [2019] 3 SLR 431 (“*Nurun Novi*”) at [50]-[51]. The legal position is that it is only necessary to show an appreciation of the risk to safety and not of the Accident.

“diminished or affected” by the acts of another employee or superior. In my view, it would be inconsistent with this parliamentary intention to find that an employee would be completely exonerated from liability under s 15(3A) of the WSHA, merely because the employee was following work orders. This is especially the case when the work orders in question were patently unsafe, and the employee in question knew that the work orders were patently unsafe.”

(emphasis added)

E. Moe and Chua XD are potentially liable under section 204A of the Penal Code

440 Moe and Chua XD are potentially liable under section 204A of the Penal Code (Cap. 224, 2008 Rev Ed) (“**Penal Code**”) for obstructing the course of justice.

441 Section 204A of the Penal Code provides:

Whoever does an act that **has a tendency to** obstruct, prevent, pervert or defeat the course of justice —

- (a) **knowing that the act is likely to** obstruct, prevent, pervert or defeat the course of justice; or

(b) **intending to** obstruct, prevent, pervert or defeat the course of justice,

shall be guilty of an offence and shall on conviction be punished with imprisonment for a term which may extend to 7 years, or with fine, or with both.

(emphasis added)

442 As explained above at [187]-[189], after the Accident, Moe deleted the following items from his mobile phone and Marimuthu's mobile phone:

(a) The photograph which showed that the wiring of the damaged Heater No. 2 had been taped together with green tape (sent by Marimuthu to Moe on 24 February 2021 at 11:13am) (the "**11:13am Photograph**"); and

(b) The message in response to the photograph which stated: "*Ok let me know ASAP*" (sent by Moe to Marimuthu on 24 February at 11:32am) (the "**11:32am Message**").

443 Moe also deleted a third item, a message which stated "*Fuck leh*" (sent by Moe to Marimuthu on 24 February at 12:09am).⁸¹¹

⁸¹¹ SS-7 (Moe), [132].

444 Moe first deleted the above messages and photograph from his mobile phone on 25 February 2021. Moe had shown Chua XD the messages and photograph on 25 February 2021 and asked whether he could delete them from his mobile phone.⁸¹² Chua XD had said yes.⁸¹³ Moe had also briefly described the contents of the messages to Chua XD by explaining that there was one message from him to Marimuthu stating “*heater ok or not*”, to which Marimuthu replied “*he was checking*”.⁸¹⁴

445 Moe then deleted the same messages and photograph from Marimuthu’s mobile phone the next day, on 26 February 2021. Moe had Marimuthu’s mobile phone because it was handed to him at the Tuas Site by an officer in the evening of 24 February 2021.⁸¹⁵ Moe had first tried to turn on Marimuthu’s mobile phone on 25 February 2021 but could not do so.⁸¹⁶ On 26 February 2021, Moe managed to charge Marimuthu’s mobile phone in Chua XD’s car.⁸¹⁷ Moe came across the messages and photograph that he had earlier deleted from his mobile phone, and asked Chua XD whether he could likewise delete the messages and photograph from Marimuthu’s phone.⁸¹⁸

⁸¹² SS-7 (Moe), [133]; SS-6 (Chua XD), [223].

⁸¹³ SS-7 (Moe), [133]; SS-6 (Chua XD), [223].

⁸¹⁴ SS-6 (Chua XD), [223].

⁸¹⁵ SS-7 (Moe), [134]; SS-6 (Chua XD), [225].

⁸¹⁶ SS-7 (Moe), [134].

⁸¹⁷ SS-7 (Moe), [134].

⁸¹⁸ SS-7 (Moe), [134]; SS-6 (Chua XD), [225].

446 At that time, Chua XD had just dropped Moe off at a canteen near Star's Changi Site while Chua XD went back to the Changi Site to meet MOM investigators regarding the incident.⁸¹⁹ Chua XD told Moe to wait for him to return and not to delete the messages and photograph in the meantime.⁸²⁰

447 When Chua XD met the MOM investigators at the Changi Site, he was asked to hand over, *inter alia*, Marimuthu's mobile phone.⁸²¹ Instead of informing the investigators that Marimuthu's mobile phone was with Moe at the time and that Moe was considering making deletions from Marimuthu's mobile phone, Chua XD lied to the investigators that he was checking on the whereabouts of Marimuthu's phone.⁸²²

448 Around the same time, before Chua XD returned to meet Moe, Moe deleted the messages and photograph from Marimuthu's mobile phone.⁸²³ Moe called Chua XD and told him that he had deleted the messages and photograph from

⁸¹⁹ SS-7 (Moe), [134]; SS-6 (Chua XD), [225]; S-289 (MOM's Investigation Report), [5.1.5(a)].

⁸²⁰ SS-7 (Moe), [134]; SS-6 (Chua XD), [225].

⁸²¹ S-289 (MOM's Investigation Report), [5.1.5(a)]; NE 27 September 2021, p. 143:11-17 (Chua XD Re-ex).

⁸²² S-289 (MOM's Investigation Report), [5.1.5(a)]; NE 27 September 2021, pp. 142:23-143:10 (Chua XD Re-ex).

⁸²³ SS-7 (Moe), [134].

Marimuthu's mobile phone.⁸²⁴ According to Moe, he made the call to Chua XD at about 5:30pm or 6pm.⁸²⁵

449 Moe subsequently passed Marimuthu's phone to Chua XD on 27 February 2021.⁸²⁶ Chua XD handed over the mobile phone to the SPF on 1 March 2021, but did not mention that Moe had made deletions from the mobile phone.⁸²⁷

450 Subsequently, at Moe's first interview with the MOM investigators on 4 March 2021, Moe was requested to export selected WhatsApp chat threads (including the photographs and videos within) from his mobile phone and send them to the investigators.⁸²⁸ Moe accordingly exported and sent the selected WhatsApp chat threads but he did not mention that he had made deletions from his WhatsApp chat with Marimuthu.⁸²⁹ It was only at his second interview with the investigators on 13 April 2021 that Moe disclosed the deletions.⁸³⁰

451 The 11:13am Photograph and the 11:32am Message which Moe deleted pertained to evidence relating to the contemporaneous acts and knowledge of Moe and Marimuthu just before the Accident. Although Chua XD claims not to have

⁸²⁴ SS-7 (Moe), [134]; SS-6 (Chua XD), [226].

⁸²⁵ NE 30 September 2021, pp. 104:20-105:12 (Moe Re-ex).

⁸²⁶ SS-7 (Moe), [134]; SS-6 (Chua XD), [227].

⁸²⁷ NE 27 September 2021, p. 146:18-23 (Chua XD Re-ex).

⁸²⁸ S-289 (MOM's Investigation Report), [5.1.5(b)].

⁸²⁹ S-289 (MOM's Investigation Report), [5.1.5(b)].

⁸³⁰ S-289 (MOM's Investigation Report), [5.1.5]; SS-7 (Moe), [135].

seen clearly the contents of what exactly Moe proposed to delete,⁸³¹ he was at least aware that they were messages between Moe and Marimuthu regarding the Mixer Machine on the day of the Accident. These constitute important information regarding the circumstances surrounding the Accident. It goes without saying that without this evidence, investigations may be impeded.

452 Having regard to the above, Moe's act of deleting the 11:13am Photograph and the 11:32am Message, and Chua XD's act of lying to MOM investigators about the whereabouts of Marimuthu's phone and his further omission to inform the MOM and SPF investigators about Moe's deletions, are potentially caught by section 204A of the Penal Code.

453 As regards their respective *mens rea*:

(a) Moe claims that he was panicked and scared that he was the last person to communicate with Marimuthu before the Accident, and so he deleted his last few messages with Marimuthu.⁸³² However, it is telling that Moe only deleted selective messages from his conversation with Marimuthu and in fact did not delete his very last message to Marimuthu.⁸³³ Even if Moe was panicked or scared at the time of the deletions as claimed, it was

⁸³¹ SS-6 (Chua XD), [223].

⁸³² NE 30 September 2021, pp. 129:6-130:12 (Moe XX).

⁸³³ S-30, IM#267.

more likely to be a panic or fear that investigators would uncover Moe's involvement in the lead-up to the Accident. Moe plainly intended to impede investigations. In this regard, it is immaterial that Moe subsequently informed the MOM investigators of his deletions – Moe's intention is to be adjudged at the time he made the deletions.

(b) Chua XD claims that he had no intention to hide anything and that he considered that it was up to Moe to decide what he wanted to do regarding the deletions he made.⁸³⁴ In this regard, even if Chua XD may not have intended to impede investigations, he would have known that his failure in not disclosing the deletions were likely to impede investigations (as envisaged by section 204(A)(a) of the Penal Code).

VI. TOR B: RECOMMENDATIONS TO PREVENT THE RECURRENCE OF SUCH AN ACCIDENT AT WORKPLACES

454 Finally, we consider TOR B on recommendations to prevent the recurrence of such an accident at workplaces.

455 The IC had invited written representations to prevent the recurrence of such an accident at workplaces, on the following areas which are of particular interest to the IC:

⁸³⁴ NE 27 September 2021, pp. 138:21-139:13 (Chua XD XX); pp. 142:23- 144:11; p. 147:15-19 (Chua XD Re-ex).

(a) Measures to ensure the safe commissioning, operation, maintenance, and repair of industrial machines operating in a similar manner as that involved in the incident; and

(b) Measures to ensure the safe supply, storage, and handling of combustible dust or powders at workplace settings similar to that involved in the incident.

456 As stated above at [18]-[19], a total of 17 organisations and individuals submitted written representations, of which seven representatives from various organisations were invited to share their views before the IC.

457 The recommendations made can be broadly divided into the following three categories:

- (a) Regulation and guidance;
- (b) Education and outreach; and
- (c) Cultural change and ownership.

458 We summarise the recommendations presented to the IC for each of the above categories in turn.

A. Regulation and guidance

1. Improvements to regulatory regime

459 There are improvements which can be made to the regulatory regime for both the safe operation of machinery and the mitigation of dust hazards. We will address these two areas in turn.

(a) Industrial machinery safety

(i) LEGISLATIVE REVIEW

460 Under the current regulatory framework, Stars is already subject to certain duties under the WSHA to ensure safety and health in relation to the use of all machines, including the Mixer Machine. In this regard, MOM's position is that the existing obligations under the WSHA are adequate to address Stars' lapses in relation to the Mixer Machine.⁸³⁵ This view was shared by SISO, which stated that the current regulatory landscape and support structure for Chemical Process Industry is not only adequate, but on par with requirements in other parts of the developed world.⁸³⁶

⁸³⁵ S-306, [4.5.1], S-306A, slide 15.

⁸³⁶ S-303, p. 2.

461 It is however opportune to review whether certain categories of machinery should be subject to increased regulation. MOM recommended that the Fifth Schedule of the WSHA could be reviewed and expanded to cover additional categories of machinery, such as those powered by mechanical, hydraulic, or pneumatic energy.⁸³⁷ This suggested amendment is broader than, and thus encompasses, Dr Salim's suggestion to include heated equipment or equipment with energy inputs into closed systems that could result in overheating or overpressure, in the WSHA.⁸³⁸

462 MOM's proposed expansion of the Fifth Schedule would impose more stringent duties under section 16 of the WSHA on manufacturers, suppliers, installers and persons who modify these additional categories of machinery (including machines similar to the Mixer Machine), to ensure that they are safe to use when operated properly, and that relevant information about their installation, commissioning, use, repair and modification are supplied to the buyer.⁸³⁹

463 MOM acknowledged that overseas manufacturers and suppliers would not be caught by section 16 of the WSHA unless they had a local agent or engaged a local third party to commission the machine.⁸⁴⁰ However, in MOM's view, it would

⁸³⁷ S-306, [4.8.2].

⁸³⁸ NE 16 November 2021, pp. 90:19-91:9 (MOM EIC).

⁸³⁹ S-306, [4.8.2].

⁸⁴⁰ NE 16 November 2021, pp. 138:21-139:19 (MOM, questions from IC).

be too onerous to impose the requirements for statutory equipment such as pressure vessels and lifting equipment on all machines.⁸⁴¹ There are no prevailing standards available against which to assess machines such as the Mixer Machine,⁸⁴² whose main components can be found in a wide spectrum of industrial machines in various configurations, on different scales and for different applications.⁸⁴³ It was therefore preferable to impose the duty on companies to ensure that equipment purchased is safe and of a certain integrity, such that they realise that they should take certain measures, such as certifying the equipment, or engaging an engineer or other competent persons for advice.⁸⁴⁴

464 Separately, Dr Salim had proposed that regulation 26 of the WSH (GP) Regs be amended, such that the terms “combustible liquid aerosols” and “flammable gases and vapours arising from material decomposition” be included and made explicit.⁸⁴⁵ To this, MOM stated that it would review the actual text to ascertain if the current language already covers these substances, and include them if they are not already covered.⁸⁴⁶

⁸⁴¹ NE 16 November 2021, p. 140:3-13 (MOM, questions from IC).

⁸⁴² NE 16 November 2021, p. 140:3-13 (MOM, questions from IC).

⁸⁴³ S-306, [4.8.1].

⁸⁴⁴ NE 16 November 2021, pp. 140:16-141:7 (MOM, questions from IC); S-306, [4.5.7].

⁸⁴⁵ S-300, p. 18, Table 1.

⁸⁴⁶ NE 16 November 2021, p. 94:9-23 (MOM EIC).

465 MOM recognised that these proposed changes to the law would not make a difference in terms of incident reporting obligations.⁸⁴⁷ For example, there is currently an obligation to report a “dangerous occurrence”,⁸⁴⁸ but MOM explained that near-misses such as the fire on the Mixer Machine would not come under that obligation.⁸⁴⁹ MOM explained that it would be overly onerous to require all near-misses to be reported, given the broad scope of what constitutes a “near miss”. Nevertheless, this was something MOM was prepared to look into.⁸⁵⁰

(ii) APPROVED CODES OF PRACTICE (“**ACOP**”) AND OTHER GUIDANCE DOCUMENTS

466 It was highlighted by various organisations that the list of ACOPs would need to be updated, and that the current ACOPs and guidance documents would need to be reviewed, to account for technological developments and changes in practice in relation to the safe operation of machinery.

467 It was stated by SMF that SS 537: Part 1:2008, which is the “Code of practice for the safe use of machinery” (“**SS 537:1**”) should be reviewed and updated,⁸⁵¹ because there are new challenges in terms of how machinery is

⁸⁴⁷ NE 16 November 2021, p. 134:14-18 (MOM, questions from IC)

⁸⁴⁸ Regulation 5(1) of the Workplace Safety and Health (Incident Reporting) Regulations (Cap. 354A, Rg 3).

⁸⁴⁹ NE 16 November 2021, p. 136:2-24 (MOM, questions from IC).

⁸⁵⁰ NE 16 November 2021, p. 136:21-14 (MOM, questions from IC).

⁸⁵¹ S-301, [2.2].

purchased from overseas, SS 537:1 was published back in 2008 and needs to be updated, and it primarily deals with mechanical hazards only.⁸⁵² Dr Salim opined that SS 537:1 would need to be reviewed to cover heated equipment, with particular attention given to guidance on “Information for Use”,⁸⁵³ and the “Code of Practice on Workplace Safety and Health Risk Management” published by the WSHC (“**RMCP**”) would also need to be reviewed to include guidance and examples to enable better identification of process related hazards, such as overpressure and thermal decompositions.⁸⁵⁴ WSHC agreed that SS 537:1 should be reviewed and updated with growing awareness of hazards over time,⁸⁵⁵ and the RMCP was in fact just reviewed and re-issued recently,⁸⁵⁶ and that the PHA guidelines already addressed process-related hazards.

468 Separately, while SMF had recommended that ISO 45001, which relates to “Occupational health and safety management systems – Requirements for guidance for use”, be implemented in the workplace,⁸⁵⁷ it has already been made an ACOP and was published in 2018.⁸⁵⁸

⁸⁵² NE 15 November 2021, pp. 63:14-65:11 (SMF EIC).

⁸⁵³ S-300, p. 10:10-14.

⁸⁵⁴ S-300, p. 10:19-24.

⁸⁵⁵ NE 16 November 2021, p. 44:12-23 (WSHC EIC).

⁸⁵⁶ NE 16 November 2021, p. 47:7-12 (WSHC EIC).

⁸⁵⁷ S-301, [2.8]-[2.9].

⁸⁵⁸ WSH (Approved Codes of Practice) Notification 2021, The Schedule S/N 81.

469 Dr Salim had initially suggested that some other parts of the WSHA should be amended to enhance the regulatory regime in respect of industrial machinery. However, there was eventual agreement between MOM and Dr Salim that supplementing or reviewing the current ACOPs and other relevant guidelines would also be a viable solution to address the same concerns:

No	Provision	Dr Salim's proposed amendment ⁸⁵⁹	Alternative to proposed amendment	Dr Salim's views on alternative
1	Section 17, WSHA	To enhance by including key commissioning components such as equipment/process design and information review, determination of system boundary limits, inspection and acceptance testing, safe start-up and documentation.	To have the key commissioning components included in an ACOP such as the RMCP instead of within the WSHA. This allows faster updates to keep up with technological changes. ⁸⁶⁰	This will be acceptable, as commissioning is already implied in the current WSHA. ⁸⁶¹

⁸⁵⁹ S-300, p. 18, Table 1.

⁸⁶⁰ NE 16 November 2021, p. 93:2-14 (MOM EIC).

⁸⁶¹ NE 15 November 2021, p. 34:8-15 (Dr Salim EIC).

No	Provision	Dr Salim’s proposed amendment ⁸⁵⁹	Alternative to proposed amendment	Dr Salim’s views on alternative
2	WSH (GP) Regs	To include suitable control measures and maintenance requirements.	To be addressed through enhancing risk assessment protocol requirements, and to review the RMCP and Workplace Safety and Health Guidelines on Process Hazard Analysis published by the WSHC (“ PHA guidelines ”) instead. ⁸⁶²	The RMCP, being an ACOP, is of very general applicability and hence may overlook particular process-related hazards. ⁸⁶³ On the other hand, the PHA guidelines, while attuned to processes, may be too onerous for a majority of companies and industries. ⁸⁶⁴ It would be good to

⁸⁶² NE 15 November 2021, pp. 38:4-40:22 (Dr Salim EIC).

⁸⁶³ NE 15 November 2021, p. 41:1-16 (Dr Salim EIC).

⁸⁶⁴ NE 15 November 2021, pp. 41:17-43:11 (Dr Salim EIC).

No	Provision	Dr Salim’s proposed amendment ⁸⁵⁹	Alternative to proposed amendment	Dr Salim’s views on alternative
				incorporate elements from the two for a middle-ground RA guide that is general enough for most companies, while simultaneously allowing process-related hazards to be more easily identified. ⁸⁶⁵

(iii) CERTIFICATION OF MACHINERY

470 It was recommended by IES that equipment like the Mixer Machine should be reviewed by at least one competent third party, and that owners/operators should have to appoint a qualified engineer, technologist or technician to operate the

⁸⁶⁵ NE 15 November 2021, p.42:10-17 (Dr Salim EIC).

machine.⁸⁶⁶ SMF took a similar view, in stating that machines which are sourced outside Singapore could be subjected to third party inspection services before shipment to Singapore, and that machines shall be subjected to field safety tests at the point of installation.⁸⁶⁷ SISO also suggested that the idea of having a “safety mark accreditation” for dust/powder handling related equipment and machinery could be explored.⁸⁶⁸

471 While MOM has recommended encouraging buyers of industrial equipment to have it certified to SS 537:1 standards, it did not recommend mandating third-party certification of after-sales for all types of machines, as it would be too onerous and impractical, and the industry must take ownership to ensure the safety of the machinery and the equipment that they use.⁸⁶⁹ MOM indicated that it was willing to work with Enterprise Singapore (“ESG”) to develop such a certification regime.⁸⁷⁰ MOM further explained that this could involve MOM working with the Singapore Accreditation Council once the scheme is put in place, such that the bodies responsible for certifying equipment as compliant with SS 537:1 standards are accredited.⁸⁷¹

⁸⁶⁶ S-302, p. 2.

⁸⁶⁷ S-301, [3.1] and [4.4].

⁸⁶⁸ S-303, p. 7.

⁸⁶⁹ NE 16 November 2021, p. 82:7-13 (MOM EIC).

⁸⁷⁰ NE 16 November 2021, p. 83:3-13 (MOM EIC).

⁸⁷¹ NE 16 November 2021, pp. 88:13-89:12 (MOM EIC).

(b) *Mitigation of dust hazards*

472 Having considered how the regulatory regime for industrial machinery safety may be enhanced, we next turn to the regulatory framework in respect of the safe handling of combustible dusts.

(i) LEGISLATIVE REVIEW

473 As discussed at [292] above, the secondary combustible dust explosions were attributable to the inadequate ventilation conditions at the Tuas Site workshop, coupled with the workers' unsuitable housekeeping routine. As explained at [411] above, this was a result of Stars' failure to comply with the measures specified in the Combustible Dust Circular.

474 MOM acknowledges that more can be done to enhance the regulatory regime with regard to the import and supply, bulk storage, and usage of combustible dusts. To that end, MOM has suggested that labelling requirements could be imposed for a prescribed list of combustible dusts (*eg.* those with Kst value > 100) that are packed in quantities over a prescribed limit (*eg.* >25 kg). Registration, reporting and notification requirements could also be imposed on companies which use a prescribed amount of combustible dusts, and these companies could be

ascertained via the sharing of information between agencies which currently regulate combustible dusts.⁸⁷²

475 SCDF had initially suggested that all workplaces which handle combustible dusts should be subject to the workplace safety and health management system and audit regime which is currently in place for selected workplaces (*eg*, shipyards, factories engaged in manufacturing of petroleum/petrochemical products).⁸⁷³ When asked whether MOM's tiered approach based on the K_{st} value of the dust, which measures combustibility, and the quantity of combustible dusts used or stored, and imposing notification requirements, would address this concern, SCDF stated that the broad concept of a risk-based approach sounds correct,⁸⁷⁴ and that this suggestion was made without drilling down to the specific implementation details.⁸⁷⁵

(ii) GAZETTING SS 667 AS AN ACOP

476 It was recommended by Dr Salim,⁸⁷⁶ IES⁸⁷⁷ and SMF⁸⁷⁸ that the SS 667 should be made an ACOP, to provide practical guidance with regard to the

⁸⁷² S-306, [3.5]-[3.8], S-306A, slide 9.

⁸⁷³ S-304, [11].

⁸⁷⁴ NE 16 November 2021, p. 26:7-22 (SCDF EIC).

⁸⁷⁵ NE 16 November 2021, p. 24:16-20 (SCDF EIC).

⁸⁷⁶ S-300, p. 18, Table 1.

⁸⁷⁷ S-302, p.5, [2].

⁸⁷⁸ S-301, p. 2, [2.7].

requirements of the WSHA relating to safety, health and welfare at work.⁸⁷⁹ SCDF has already incorporated SS 667 into its processes, in issuing a Circular on 1 June 2021 stating that SS 667 would apply to all new buildings and buildings undergoing fire safety works that store flammable powders.⁸⁸⁰ This is in line with MOM and WSHC's stated intention to have SS 667 gazetted as an ACOP,⁸⁸¹ which has been done on 19 November 2021.⁸⁸²

2. Guidance for small and medium enterprises ("SMEs")

477 One issue of concern raised during the Inquiry was that, while large corporations are able to readily navigate and comply with the various industry guidelines and ACOPs such as the SS 667 and SS 537:1, it may not be as easy for SMEs like Stars, with typically limited resources, to effectively digest and implement these guidelines at their workplaces.

(a) Publication or review of guidance documents

478 There is room for more guidance documents, in particular those targeted / catered towards SMEs, to be published or reviewed. Dr Salim had recommended that a guidance document be developed on commissioning best practices for

⁸⁷⁹ Section 40B of the WSHA.

⁸⁸⁰ S-304, [8].

⁸⁸¹ S-306, [3.4.6]; NE 16 November 2021, p. 44:3-11 (WSHC EIC).

⁸⁸² WSH (Approved Codes of Practice) Notification 2021, The Schedule S/N 76.

SMEs.⁸⁸³ SISO had recommended that guides be issued for SMEs covering aspects such as safe operation, commissioning, maintenance and repair, management of change, training, risk assessment, and various aspects relating to combustible dust.⁸⁸⁴ SISO further opined that the WSH guidelines for the safe use of machinery need to be amended to include handling of materials.⁸⁸⁵ WSHC agreed that the guidelines for the safe use of machinery need to be updated to include unauthorised maintenance and replacement of parts.⁸⁸⁶

479 WSHC additionally agreed that the guidelines should be updated to take into account the dust-safety measures in SS 667.⁸⁸⁷ SMF also indicated that it was open to developing such guidance documents with WSHC.⁸⁸⁸

(b) Advisory panel

480 It was recommended by SISO that an advisory panel can also be set up for SMEs, modelled after the panel which reviews major hazard installations, so that there could be a single window with all regulatory bodies and stakeholders represented, possibly within the WSHC, to guide the SMEs during set-up and

⁸⁸³ S-300, p. 11:7-12.

⁸⁸⁴ S-303.

⁸⁸⁵ NE 15 November 2021, p. 154:18-22 (SISO EIC).

⁸⁸⁶ NE 16 November 2021, pp. 44:24-45:8 (WSHC EIC).

⁸⁸⁷ NE 16 November 2021, p. 45:14 (WSHC EIC).

⁸⁸⁸ NE 16 November 2021, p. 72:6-13 (MOM EIC).

operations.⁸⁸⁹ SISO explained that the intent behind this recommendation was not to increase regulation, but to have guidance available.

481 SMF agreed that such a panel would be useful, and SMF could even organise training courses if SMEs would like to be trained on how to conduct explosion protection or machinery evaluation risk assessments properly.⁸⁹⁰ SCDF opined that it was open to the idea, though whether this is an entirely new panel or rides upon existing panels or committees needs to be studied further.⁸⁹¹

482 WSH indicated that it was always looking at how it could enhance its outreach and messaging, and that having individuals from SMEs who are influential and well-networked in its industry committees would be a good idea.⁸⁹² However, WSHC opined that it may be better to have SME outreach via its industry committees than to go through the Association for Small and Medium Enterprises or to set up a dedicated SME panel, because there are procurement linkages within the industry, and the risks and control measures are industry-specific for the type of operations and equipment used.⁸⁹³ This view was shared by MOM, which also opined that it was more sustainable to have a hub-and-spoke model, as it would be

⁸⁸⁹ S-303, p. 2.

⁸⁹⁰ NE 15 November 2021, p. 71:7-16 (SMF EIC).

⁸⁹¹ NE 16 November 2021, pp. 18:18-19:12 (SCDF EIC).

⁸⁹² NE 16 November 2021, p. 42:8-13 (WSHC EIC).

⁸⁹³ NE 16 November 2021, pp. 41:2-42:21 (WSHC EIC).

a herculean task to ensure that a standalone panel for SMEs is sufficiently sized, resourced, and competent to take care of the diverse needs of SMEs.⁸⁹⁴

(c) *bizSAFE as guidance for safety processes*

483 In terms of safety processes, SISO proposed that high hazard process SMEs should be required to have a minimum of bizSAFE Level 3 certification, before they are allowed to start.⁸⁹⁵

484 In response, WSHC stated that bizSAFE, which it administers, is not meant to be used as a regulatory tool, as it is meant to be used for capability development and training. As what is prescribed is the *outcome* of having a safety and health management system, WSHC does not prescribe the means by which workplaces attain this, and bizSAFE is one of the available pathways.⁸⁹⁶ This is especially since there are other frameworks, such as overseas practices and ISO documents available.⁸⁹⁷ WSHC has instead worked with companies to promote bizSAFE, by encouraging big players to expect bizSAFE 3 standards from their subcontractors, and having government procurement agencies requiring bizSAFE 3, to promote bizSAFE adoption among SMEs.⁸⁹⁸

⁸⁹⁴ NE 16 November 2021, pp. 114:19-116:11 (MOM EIC).

⁸⁹⁵ S-303, p. 2.

⁸⁹⁶ NE 16 November 2021, pp. 35:13-36:25 (WSHC EIC).

⁸⁹⁷ NE 16 November 2021, p. 37:1-9 (WSHC EIC).

⁸⁹⁸ NE 16 November 2021, p. 38:7-23 (WSHC EIC).

485 MOM was of a similar view, in that it agreed with the conceptual thrust of SISO's recommendation to have some sort of certification showing a company's ability to manage the risk of high hazard processes, but that it need not necessarily be bizSAFE.⁸⁹⁹ MOM added that making bizSAFE mandatory may have the opposite effect in having companies comply with it without internalising the concept and intent of managing risks behind it, which goes against the idea of having a culture of ownership by the industry to manage its own risks.⁹⁰⁰

B. Education and outreach

486 It was recognised by various organisations that education plays a key role in propagating safety practices through industry. SMF had encapsulated it succinctly, in stating that safety is a mindset, one can only regulate that much, but eventually workplace safety and health (WSH) is attained through awareness and education.⁹⁰¹ While there have been comprehensive efforts to reach out to employers and employees across various platforms, there is still more which can be done.

⁸⁹⁹ NE 16 November 2021, pp. 113:22-114:18 (MOM EIC).

⁹⁰⁰ NE 16 November 2021, p. 113:1-21 (MOM EIC).

⁹⁰¹ NE 15 November 2021, p. 69:8-11 (SMF EIC).

1. Current efforts

(a) General safety outreach

487 One of WSHC's main roles is to educate employers and employees on how to improve WSH, through industry events, promotional material and resources. The WSHC has carried out extensive efforts in this area. As stated in its submission, it administers the safety orientation course for workers in high-risk environments, and the settling-in programme for workers in the construction, manufacturing, marine and process industries.⁹⁰² In both these courses, workers are told to contact MOM or the Migrant Workers Centre if they see any unsafe work practices.⁹⁰³

488 There are 56 other courses accredited by WSHC, which attracted over 300,000 workers in 2019.⁹⁰⁴ WSHC works with industry associations and unions to disseminate WSH guidelines and other information, and uses its WSH Bulletin to inform its 75,000 subscribers.⁹⁰⁵ It issues circulars to inform all employers when there are critical updates.⁹⁰⁶ It has also started using the FWMOMCare app to send all 600,000 work permit holders WSH education in their native languages.⁹⁰⁷

⁹⁰² S-305, pp. 1-2.

⁹⁰³ S-305, pp. 1-2.

⁹⁰⁴ S-305, pp. 1-2.

⁹⁰⁵ S-305, p. 3.

⁹⁰⁶ S-305, p. 3.

⁹⁰⁷ S-305, p. 3.

489 Apart from these formal channels, WSHC also utilises its Facebook page which has 33,000 followers,⁹⁰⁸ and engages social media platforms that are popular within the migrant worker community, such as influencers or certain Facebook pages in their native languages, so that safety messages can be disseminated.⁹⁰⁹

(b) Inspections for combustible dust hazards

490 For MOM, it has conducted special enforcement operations in March 2021 codenamed “Operation Bullfinch 2” to assess the adequacy of safety measures to address risks associated with dust explosion hazards in the manufacturing industry. This involved the inspection of approximately 500 companies that potentially deal with combustible dust, with a specific focus on SMEs.⁹¹⁰

491 MOM found that most companies showed low awareness of combustible dust hazards, as evident from the lack of identification of combustible dust hazards in their risk assessments.⁹¹¹ This is despite the issuance of the Combustible Dust Circular on 23 July 2015.⁹¹² Larger companies, in contrast, generally had identified

⁹⁰⁸ NE 16 November 2021, p. 33:20-21 (WSHC EIC).

⁹⁰⁹ NE 16 November 2021, pp. 34:18-35:2 (WSHC EIC).

⁹¹⁰ S-306, p. 6, [2.2.1].

⁹¹¹ S-306, p. 6, [2.2.2].

⁹¹² S-233.

combustible dust hazards in their risk assessments, and had the necessary control measures in place.⁹¹³

2. Proposed improvements

(a) General safety training and dissemination of information

492 In its submission, WSHC has recognised that the training currently available is front-loaded, and the lessons may not be reinforced throughout the workers' career. WSHC therefore suggests that workers in higher-risk industries should be required to attend refresher WSH training at regular milestones.⁹¹⁴

493 WSHC elaborated at the hearing on further efforts to reach out to workers and SMEs. WSHC would ramp up and more deliberately and consciously think about messaging and outreach to the SME segment within each industry.⁹¹⁵ WSHC also stated that it has been thinking about translating worker-level communications into their native languages, and even utilising videos, which workers are more amenable to consuming.⁹¹⁶ WSHC ultimately aims to get as pervasive an outreach as possible, even though it would be challenging to reach 100% coverage. WSHC

⁹¹³ S-233.

⁹¹⁴ S-305, p. 4.

⁹¹⁵ NE 16 November 2021, p. 41:12-15 (WSHC EIC).

⁹¹⁶ NE 16 November 2021, p. 53:1-12 (WSHC EIC).

is keen to explore good ways to increase coverage, especially among the comparatively “less touched” group.⁹¹⁷

494 This can be complemented by the efforts of other institutions. SMF has indicated its willingness to work with MOM, and key organisations such as ESG, SISO, National Safety Council of Singapore, and WSHC to further promote and create awareness of safety standards and culture in the workplace.⁹¹⁸ It also suggested that one possible way to reach out to the workers would be to have a third party to speak to the workers periodically, so that they have a means to whistle blow on unsafe practices.⁹¹⁹

(b) Increasing awareness of combustible dust hazards

495 As regards awareness of combustible dust hazards, WSHC stated that there was the intention to produce infographics and simplified collaterals summarising the key points in SS 667,⁹²⁰ for SMEs to more easily digest and implement the relevant measures at their workplaces.

496 IES suggested tapping on the list of companies inspected under Operation Bullfinch 2 to train the owners and supervisors on the safe use of combustible

⁹¹⁷ NE 16 November 2021, p. 51:14-23 (WSHC EIC).

⁹¹⁸ S-301, [1.3].

⁹¹⁹ NE 15 November 2021, pp. 90:20-91:14 (SMF, questions from IC).

⁹²⁰ NE 16 November 2021, pp. 49:15-51:1 (WSHC EIC).

dust.⁹²¹ IES also suggested that the IECEx certification scheme could be tapped upon to train competent personnel on dust explosion risks.⁹²²

497 SISO has indicated that it will review its career progression pathway,⁹²³ and focus on approaching SMEs so that they will receive the collaterals which SISO produces.⁹²⁴

C. Cultural change and ownership

498 It was recognised by multiple institutions that safety was ultimately a way of thinking, and that a sense of ownership was required over health and safety on the part of both the employers and employees before the current situation would improve. As stated by SMF, safety is always about three things, namely people, processes and policies, with the key being people.⁹²⁵ SISO took the same view, in stating that culture is ultimately habits repeated,⁹²⁶ and that there can be thought on how a cultural programme like what the Singapore Chemical Industry Council has, but is fit for SMEs, could be implemented.⁹²⁷

⁹²¹ NE 15 November 2021, p. 137:5-18 (IES, questions from IC).

⁹²² S-302, p. 4.

⁹²³ NE 15 November 2021, p. 159:19-24 (SISO EIC).

⁹²⁴ NE 15 November 2021, p. 162:4-17 (SISO EIC).

⁹²⁵ NE 15 November 2021, p. 72:8-13 (SMF EIC).

⁹²⁶ NE 15 November 2021, p. 159:16 (SISO EIC).

⁹²⁷ NE 15 November 2021, p. 165:1-14 (SISO EIC).

499 Strengthening WSH ownership is accordingly one of the central planks of the WSH 2028 national strategy, to make WSH more salient in business decisions, align company directors and top management to WSH ownership, and strengthen WSH ownership of workers.⁹²⁸ It is evident from current observations that there is still much to be done, however, there are levers which can be utilised to make WSH financially viable for companies.

1. Current observations

500 It can be seen by this Accident that WSH has not been ingrained as part of Stars' culture. Within Stars itself, as stated above at [65], there was little training given for safety within the Tuas Site. The employees did not raise the alarm in respect of what they observed to the authorities, despite having attended the safety orientation course, and hence being aware of the avenues to report red flags. Even when Marimuthu raised his concerns to Chua XD, he was persuaded to continue working. Having three persons trained as safety supervisors on the Tuas Site did not result in the issues with the Mixer Machine being picked up and addressed adequately, which ultimately resulted in three deaths and seven others injured.

501 Stars is a prime example of a company which had complied with safety requirements on paper, being bizSAFE Star⁹²⁹ qualified, and personnel trained in

⁹²⁸ S-306A, slide 4.

⁹²⁹ SS-6 (Chua XD), [13].

risk management and safety, but did not implement health and safety measures adequately in practice. This supports the view of MOM that it would not do to have companies comply with regulatory practices for the sake of compliance without having a sense of ownership.⁹³⁰

502 The same can be said of SMEs in general. The reasons for SMEs not prioritising WSH are manifold. As stated by SMF, SMEs would not put WSH as a priority if there was no regulatory motivation to do so, and there is a trade-off between increasing regulation and the (financial) burden on their existing business.⁹³¹ IES opined that SMEs may not be fully aware of guidelines and requirements, thus more is needed to be done to educate and motivate smaller factory operators to comply with existing regulatory requirements.⁹³² SISO shared this view, in that no worker starts off wanting to have an accident, but they lack the knowledge and competence.⁹³³ For employees, apart from requiring the knowledge and competency to identify problems, the other issue to be addressed is the general power imbalance between the employer and the employee, particularly for migrant workers.⁹³⁴

⁹³⁰ NE 16 November 2021, p. 113:8-21 (MOM EIC).

⁹³¹ NE 15 November 2021, pp. 72:20-73:12 (SMF EIC).

⁹³² NE 15 November 2021, p. 99:14-20 (IES EIC).

⁹³³ NE 15 November 2021, p. 156:12-19 (SISO EIC).

⁹³⁴ NE 16 November 2021, p. 132:10-24 (MOM, questions from IC).

2. *Possible improvements*

503 Unfortunately, there is no ready solution to issues of culture and ownership. As stated candidly by WSHC, its push in creating information to be disseminated has to be complemented by willingness on the part of companies to want to consume this information.⁹³⁵ It is also very difficult to legislate for “sins of omission”, which WSH issues tend to fall under, because much of it is dependent on the internal motivation of companies to want to do their best in the area, and not merely meet legislative minimum standards.⁹³⁶

504 There are three main areas to consider focussing on to prevent recurrences of similar accidents. The first is to foster a culture of trust and care in the workplace. As stated by SISO, it is not just about hard competence but the softer skills as well, and gave the example of some industries which carry out listening tours, where they find out how the workers are doing without speaking about work,⁹³⁷ so that workers feel cared for. This was echoed by MOM: while whistleblowing mechanisms are available, the first response by the worker upon sight of unsafe practices should be to flag them to the boss, rather than calling MOM, as the latter would set up a very unhealthy workplace dynamic.⁹³⁸ What is needed is for the employer and employee

⁹³⁵ NE 16 November 2021, p. 54:2-5 (WSHC EIC).

⁹³⁶ NE 16 November 2021, pp. 58:12-59:8 (WSHC EIC).

⁹³⁷ NE 15 November 2021, p. 168:13-20 (SISO, questions from IC).

⁹³⁸ NE 16 November 2021, p. 125:6-14 (MOM, questions from IC).

to work together, trust each other and look after each other's back,⁹³⁹ and this could be one of the building blocks towards building a safer culture.

505 Second, the competencies and accountability of senior leadership within the workplace need to be addressed. Many stakeholders, including safety officers, had provided feedback during a consultation exercise on the WSH 2028 national strategy that convincing and influencing the leadership to allocate sufficient resources and time to safety is crucial.⁹⁴⁰ While competencies are important, with the WSHC having training programmes and dialogues with industry to foster this,⁹⁴¹ accountability also needs to be fostered. In this respect, MOM is working on a Code of Practice for company leadership and directors, which would set out what is reasonably practicable and expected at the leadership level, so that safety and health would be part of the agenda in board discussions, resources and time for WSH are adequately allocated, and internal processes for discussing and learning from accidents and near-misses are instituted.⁹⁴²

506 Third, there can be financial and regulatory levers to motivate compliance, so that companies realise that it is in their financial interest to institute safe processes in the workplace. Apart from encouraging large players to make bizSAFE

⁹³⁹ NE 16 November 2021, p. 125:15-21 (MOM, questions from IC).

⁹⁴⁰ NE 16 November 2021, p. 62:11-18 (WSHC, questions from IC).

⁹⁴¹ NE 16 November 2021, pp. 62:19- 63:15 (WSHC, questions from IC).

⁹⁴² NE 16 November 2021, pp. 63:6-64:13 (WSHC, questions from IC).

a requirement in contracting as addressed at [484] above, SMF suggested that going for safety training could be made a requirement before contracts are awarded.⁹⁴³ IES also suggested that the ecosystem could allow for returns on the safety training investment, by working with insurance companies, such that premiums are reduced if the equipment is certified by the insurer.⁹⁴⁴ This is mutually beneficial as the insurers are aware that the equipment has been certified to their standards, while the company benefits from having other costs reduced due to their compliance with safety.

507 The authorities have already started moving in this direction. The Work Injury Compensation Act 2019 was recently amended to require all work injury compensation insurers to share their claims data with other insurers, so that insurers have a more complete track record.⁹⁴⁵ This allows safer firms to benefit from cheaper premiums and vice versa,⁹⁴⁶ and also enables IES' suggestion on reduction of premiums to be implemented, as companies are no longer able to switch insurers and make false declarations on their accident record.⁹⁴⁷

⁹⁴³ NE 15 November 2021, p. 82:11-16 (SMF EIC).

⁹⁴⁴ NE 15 November 2021, p. 132:8-23 (IES EIC).

⁹⁴⁵ NE 16 November 2021, pp. 54:20-55:6 (WSHC EIC).

⁹⁴⁶ NE 16 November 2021, p. 55:7-13 (WSHC EIC).

⁹⁴⁷ NE 16 November 2021, p. 56:3-15 (WSHC EIC).

508 Ultimately, as stated by MOM, there is no panacea to the issues of ownership and culture.⁹⁴⁸ MOM has been working for the past 20 years to put in place the outcome-based laws, providing guidance, getting industry to take leadership and ownership.⁹⁴⁹ However, top management must also be interested enough to utilise these resources given.⁹⁵⁰ It is a continuous journey to build a safety culture,⁹⁵¹ and the work is not done if such accidents still occur and there is that one company which does not take ownership and does not take health and safety seriously.⁹⁵²

D. Summary of recommendations

509 To summarise, there is room for the law to be amended so that there is greater oversight of the use and storage of combustible dusts, and to include more types of machines in the Fifth Schedule to the WSHA, such that the safe installation, supply and maintenance of such machines would also come under regulatory control. It is also time for the ACOPs to be updated, and more guidance materials which cater to the needs of the workers to be produced and disseminated. The authorities continue to explore new ways of reaching all employees and industries, with a focus on SMEs which are not currently subject to increased regulation. The

⁹⁴⁸ NE 16 November 2021, p. 122:2-25 (MOM, questions from IC).

⁹⁴⁹ NE 16 November 2021, p. 123:7-10 (MOM, questions from IC).

⁹⁵⁰ NE 16 November 2021, p. 124:10-17 (MOM, questions from IC).

⁹⁵¹ NE 16 November 2021, p. 123:17-18 (MOM, questions from IC).

⁹⁵² NE 16 November 2021, p. 123:11-16 (MOM, questions from IC).

work to build up a safety culture and instil a sense of WSH ownership in both employers and employees is not complete, and efforts will continue, in line with what has been stated in the WSH 2028 national strategy.

VII. CONCLUSION

510 This tragic Accident was an unfortunate and needless loss of lives. It is a sober reminder that no workplace is inherently safe. Employers and employees alike are duty bound to make and keep the workplace safe for everyone.

511 In this case, Stars failed its workers. First, Stars made several misguided assumptions about the safe use of the Mixer Machine. Second, even in the face of red flags and near-misses involving the Mixer Machine, Stars continued to hold on to its misguided assumptions. Third, even as the Mixer Machine was plainly beginning to fail, Stars was content to stick on band-aids and persist in using the Mixer Machine, simply waiting for the next accident to occur. Fourth, this was compounded by Stars' failure to take all necessary precautions against combustible dust hazards, despite being in the know of the Combustible Dust Circular.

512 Ultimately, Stars and its management are squarely to blame for the Accident. The workers, and their families, have had their lives forever changed as a result. The deaths and injuries suffered by these migrant workers, who left their friends and loved ones back home to pursue their livelihoods, were entirely and easily preventable.

513 There will no doubt be many important lessons to learn from this tragic accident, to ensure it is never again repeated. The IC's report will be invaluable in this regard.

Dated this 10th day of December 2021.

KTM

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IN THE STATE COURTS OF THE REPUBLIC OF SINGAPORE

**INQUIRY UNDER SECTION 26 OF
THE WORKPLACE SAFETY AND HEALTH ACT (CAP. 354A)
INTO THE FATAL ACCIDENT AT STARS ENGRG PTE LTD'S WORKPLACE
AT 32E TUAS AVENUE 11**

**INTERESTED PARTY'S WRITTEN SUBMISSIONS
TO THE INQUIRY COMMITTEE**

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Dated this 10th day of December 2021

TABLE OF CONTENTS

I.	INTRODUCTION	3
II.	THE INQUIRY PROCEEDINGS	7
III.	VERACITY OF THE MANUFACTURER’S EVIDENCE	12
	A. <i>Minimal weight, if any, should be accorded to the Manufacturer’s email responses</i>	12
	B. <i>There are inconsistencies between the Manufacturer’s responses and the objective evidence</i>	14
	C. <i>The Manufacturer’s responses are self-serving and unreliable</i>	14
IV.	THE CAUSES AND CIRCUMSTANCES OF THE ACCIDENT.....	15
	A. <i>Whether the explosion occurred inside or outside the Mixer Machine</i>	15
	B. <i>There is no reliable evidence of secondary deflagrations </i>	18
	C. <i>Other technical aspects of the Accident</i>	23
V.	CONCLUSION	27

I. INTRODUCTION

1. These are Stars Engrg Pte Ltd's ("**Stars Engrg**") written submissions to the Inquiry Committee for the purpose of the Inquiry convened under section 26 of the Workplace Safety and Health Act (Cap. 354A) ("**WSHA**") into the fatal accident ("**Accident**") that occurred at its workplace at 32E Tuas Avenue 11 ("**Workplace**") on 24 February 2021 ("**Inquiry**").
2. On 24 February 2021 at about 11.25 am, an explosion occurred at the Workplace that was occupied by Stars Engrg. At the material time, employees of Stars Engrg were working at the Workplace. Preliminary investigations by the authorities revealed that these employees were working on sigma kneader mixer machine ("**Mixer Machine**") when the explosion occurred.
3. As a result of the accident, eight Stars Engrg employees suffered burns and were taken to the Singapore General Hospital. Three workers eventually succumbed to their injuries.
4. On 2 March 2021, the Minister for Manpower, Mrs. Josephine Teo, appointed an Inquiry Committee under the WSHA to examine the causes and circumstances that led to the Accident.
5. The parties to this Inquiry include (a) a team of State Counsel from the Attorney-General's Chambers ("**AGC**") led by Ms Kristy Tan, S.C.,

appointed to assist the Inquiry Committee by leading evidence under the Terms of Reference (“**ToR**”); and (b) Stars Engrg, appearing only as an interested party. The Accident occurred at the Workplace and the workers involved were employed by Stars Engrg. At the time of the Inquiry, neither Stars Engrg, its officers nor its employees were named as potential defendants to any criminal proceedings.

6. Bearing in mind that the primary objective of the Inquiry is to ascertain the causes and circumstances of the Accident (as set out at paragraph (a) of the Terms of Reference), we respectfully highlight that the nature of the proceedings is a fact-finding one, as opposed to fault-finding.

7. To this end, based on our instructions, our participation in the Inquiry and these submissions are strictly confined to the following selected issues for the sole purpose of assisting the Inquiry Committee in this fact-finding process:
 - a. Our broad observations on the nature of these Inquiry proceedings;

 - b. Minimal weight, if any, should be accorded to Laizhou Keda’s (the “**Manufacturer**”) evidence; and

 - c. The technical causes and circumstances of the Accident.

8. At this juncture, it bears mentioning that the Ministry of Manpower (“**MOM**”) and the AGC appear to have already determined the issue of liability, even well before the Inquiry Committee’s determination of the issues set out in the ToR. This is evident from the following events:
- a. The adversarial approach of the State Counsel at the Inquiry, very plainly pinning liability on Stars Engrg and/or its officers from the start.
 - b. Mr Chua Xing Da (“**Mr Chua**”), the owner and sole director of Stars Engrg, was placed under arrest by the police on 30 November 2021:
 - i. Mr Chua informed the police of his intention to travel to Vancouver, Canada, from 2 December 2021 to 17 December 2021. Although Mr Chua was not on bail or under any travel restrictions then, he informed the police about his impending trip for good order.
 - ii. Pursuant to Mr Chua’s instructions, his solicitors, Rajah & Tann Singapore LLP (“**R&T**”) sent a letter enclosing his travel itinerary to the police on 17 November 2021. In R&T’s letter, the police were informed that the purpose of this overseas trip was two-fold – first, to source for products and materials for his business, and second, to concurrently take

a short holiday with his wife. The police did not reply to R&T's letter dated 17 November 2021.

- iii. Just two days before Mr Chua's intended departure date, he was arrested by the police in the morning of 30 November 2021 and placed on bail. Mr Chua was informed that he is presently investigated for an alleged offence of obstruction of justice under section 204A of the Penal Code (Cap. 48). We believe that the arrest relates to the deleted messages in Mr Marimuthu's mobile phone, which the police had known well before the commencement of the Inquiry. Consequently, he was asked to surrender his passport to the police.
 - iv. In the afternoon of 30 November 2021, R&T wrote to the police and the AGC requesting for the temporary return of Mr Chua's passport for his trip. The police replied to R&T's letter on the following day on 1 December 2021 to deny Mr Chua's request even though there is no evidence that Mr Chua is a flight risk.
- c. On 3 December 2021, Stars was informed that the MOM would be preparing conditioned statements for the five workers involved in the Accident before these workers depart from Singapore. We believe that additional statements from the workers are being

prepared in anticipation of further proceedings. We have written to the MOM to inform that Stars Enrg and/or its officers will object to the admission of any evidence under section 32 of the Evidence Act (Cap. 97) and that the MOM should put in all efforts to secure their attendance at any proceedings to be initiated.

9. For the avoidance of doubt, Stars Enrg, its officers and/or its employees do not admit to any of the allegations made by the AGC during the Inquiry proceedings. Further, nothing should be construed as an admission especially where allegations that may be raised by the AGC against Stars Enrg, its officers and/or its employees are not specifically addressed in these submissions.
10. Stars Enrg, its officers and/or its employees reserve their rights to make further arguments and adduce additional evidence in response to all allegations, as well as the particulars of any charges that may be brought, during any subsequent proceedings that may be brought at a different forum for a different purpose.

II. THE INQUIRY PROCEEDINGS

11. Having regard to the capacity of Stars Enrg as an interested party, we make the following broad observations in respect of these proceedings

without prejudice to further submissions to be made by Stars Engrg at any subsequent forum, if necessary.

12. First, while the evidentiary rules as to the conduct of the Inquiry are flexible and subject to the discretion of the Inquiry Committee, the proceedings should nonetheless accord with the fundamental tenets of natural justice and due process. However, several aspects of the inquiry proceedings were troubling:
 - a. As part of the investigations arising from the Accident, the police and the MOM interviewed the officers and workers from Stars Engrg who were eventually listed as factual witnesses to give oral evidence during the first tranche of the Inquiry. Prior to the commencement of the Inquiry, members of the State Counsel team also interviewed these factual witnesses (including Mr Chua) for the purposes of preparing written witness statements to be tendered during the proceedings.
 - b. In the interest of time and expense, and bearing in mind the primary objective of the Inquiry, Stars Engrg did not object to the majority of the witness statements being tendered in evidence.¹

¹ Save for Stars Engrg's request for selected paragraphs of the five witness statements to be excluded from the written statements, and for the evidence contained in those paragraphs to be led by oral evidence instead. The Inquiry Committee acceded to Stars Engrg's request (see email from Secretariat dated 16 September 2021) despite State Counsel's objections (see AGC's letter dated 15 September 2021).

- c. During the Inquiry proceedings, as the State Counsel team presented all the evidence, the factual witnesses whose witness statements were tendered in evidence were subject to cross-examination twice by the State Counsel team.
 - d. If the AGC had determined the liability of Stars Engrg and/or its officers, they should appropriately be named as potential defendants for the purposes of the Inquiry as a matter of procedural fairness, with their evidence led by their counsel.
13. Second, it is at odds with procedural fairness that several witnesses who gave evidence on the technical causes of the explosion during the first tranche of the Inquiry were also asked to give evidence at the second tranche, which was meant to focus on industry stakeholders making recommendations or observations relating to the cause of the accident.² As an interested party in these proceedings, Stars Engrg had neither the standing nor the basis to object to the witnesses called during the second tranche of the Inquiry.
14. In the absence of any specific allegation or charge preferred against Stars Engrg and/or its officers, the Inquiry was also not the appropriate forum to make full submissions on the relevance of, or weight to be accorded to, the evidence of these witnesses. Examples of witnesses who gave evidence in both tranches of the Inquiry are:

² Paragraph (b) of the ToR to the Inquiry Committee.

- a. For the first tranche of the Inquiry, Dr Shaik Mohamed Salim (“**Dr Salim**”) prepared a report on the technical causes of the explosion³ and gave oral evidence on behalf of A* Institute of Chemical and Engineering Science (“**A*STAR**”). During the second tranche, Dr Salim was also asked to prepare a “Recommendations Report”⁴ that was premised on Dr Salim’s technical findings (which have not been adjudged on by the Inquiry Committee) in his first report.⁵ When Dr Salim gave oral evidence during the second tranche of the proceedings, he referred to the “*improper risk assessments*” and “*poor SOPs*” that were “*noted during the previous tranche*”.⁶ However, no such findings of facts were made by the Inquiry Committee. Dr Salim’s “Recommendations Report” is undoubtedly self-serving in advancing his views.
- b. During the first tranche of the Inquiry, the Singapore Civil Defence Force (“**SCDF**”) gave evidence as the first responders at the scene and prepared a Fire Investigation Report dated 14 September 2021⁷ for these purposes. For the second tranche of the proceedings, SCDF were asked to prepare a written representation

³ A*STAR’s Accident Investigation Report dated 13 September 2021 (“**A*STAR’s Report**”): S-283.

⁴ A*STAR’s Recommendations Report dated 3 November 2021 (“**A*STAR’s Recommendations Report**”): S-300.

⁵ See “Background and Introduction” at p 7 of A*STAR’s Recommendations Report that sets the parameters for Dr Salim’s recommendations to be based on his view that “*This primary deflagration event was followed up by up to three secondary deflagrations in the form of flash fires. These flash fires were likely the result of potato starch within the Stars Engng factory unit that were initially agitated and suspended by the overpressure from the primary deflagration to form a combustible dust cloud*”: S-300.

⁶ Transcript dated 15 November 2021, p 12 at ln 13 to p 13 at ln 4.

⁷ SCDF’s Fire Investigation Report dated 14 September 2021: S-288.

with “a focus on the measures to ensure the safe supply, storage and handling of combustible dust or powders at workplace settings similar to that involved” in the accident.⁸

- c. MOM representatives were asked to give evidence for both tranches of the Inquiry. For the second tranche, the divisional director of the MOM’s Occupational Safety and Health Division, Mr Silas Sng (“**Mr Sng**”), testified on behalf of the MOM. In the course of giving evidence, Mr Sng opined on how Mr Chua “*made a series of errors...and as a result did not manage the risks and that caused the accident*”.⁹ Given the MOM’s role in the second tranche of the Inquiry, it was inappropriate for Mr Sng to comment as such especially when the Inquiry Committee has not made any findings of fact. Such comments were likewise self-serving, premature and only served to prejudice Stars Engrg and/or its officers. Bearing in mind that neither Stars nor its officers were facing any criminal or regulatory charges, the intention behind the litany of such opinions is clearly to undermine the position of Stars and/or its officers.

⁸ See SCDF’s Written Representation to the Inquiry Committee for the Fatal Accident at Stars Engrg Pte Ltd on 24 February 2021 at [1]: S-304.

⁹ Transcript dated 16 November 2021, p 125 at Ins 3-6.

III. VERACITY OF THE MANUFACTURER'S EVIDENCE

15. At the heart of the accident was the Mixer Machine that Stars Engrg purchased directly from the Manufacturer. In the course of the Inquiry, the MOM investigation team corresponded by email with the Manufacturer and a series of responses from the Manufacturer by various emails were received. The email responses received from the Manufacturer have been admitted into evidence.

A. Minimal weight, if any, should be accorded to the Manufacturer's email responses

16. We submit that the evidence from the Manufacturer as disclosed in the proceedings has limited value and should be accorded with minimal weight, if any. In this regard, we are not aware of any attempt by the State Counsel or the MOM to secure the attendance (whether physical or virtually) of any representative of the Manufacturer to give oral evidence before the Inquiry Committee. This was unsatisfactory, especially since the Manufacturer would be a material witness.

17. All the email responses by the Manufacturer were admitted into evidence without the calling of a representative of the Manufacturer to be present. The veracity and credibility of the Manufacturer's evidence were therefore

untested by the usual rigours of open court proceedings including cross-examination.

18. Without the opportunity to cross-examine any representative from the Manufacturer, Stars Engrg and/or its officers were unable to question the Manufacturer on the material contradictions between its email responses to the MOM and the objective evidence. As the learned author of *Evidence and the Litigation* (LexisNexis, 2017) rightly points out at [20.001], “*Reliability can only be assessed if the parties are able to challenge each other’s evidence so that weaknesses may be exposed... Cross examination has a fundamental role in ascertaining the truth of facts.*” Accordingly, the evidence of a witness who is not cross-examined may carry insignificant weight or be wholly disregarded. Taking into account the fundamental principles of natural justice and procedural fairness, we submit that the Manufacturer’s evidence in the form of email responses must only be accorded with minimal weight, if any.
19. Notwithstanding the above, and in the light of the capacity in which Stars Engrg is participating in the Inquiry proceedings, Stars Engrg had placed on record that it should not otherwise be construed to have agreed to any position taken and/or taken to accept all the responses by the Manufacturer to be truthful and accurate. Stars Engrg reserves all its rights to make the appropriate submissions with the regard to the Manufacturer’s responses at the appropriate juncture and forum.

B. There are inconsistencies between the Manufacturer's responses and the objective evidence

20. The Manufacturer's lack of credibility is further underscored by several inconsistencies between the Manufacturer's email responses to the MOM and the objective evidence. For ease of reference, we have summarised the material inconsistencies in a table enclosed hereto at **Annex A**.

C. The Manufacturer's responses are self-serving and unreliable

21. Based on an objective review of the Manufacturer's email on 6 November 2021 requesting for responses from the MOM, it is both immediately and instinctively clear that the earlier responses provided by the Manufacturer were self-serving in nature. Having read the extensive media coverage over the explosion (as acknowledged by the Manufacturer),¹⁰ the Manufacturer's responses were crafted to negate all liability on their part. In turn, the Manufacturer's approach and inconsistent responses must raise serious questions concerning the operational reliability of the Mixer Machine in the first place.

22. In the absence of any cross-examination of the Manufacturer, we submit that it would be wholly unreliable to rely on the Manufacturer's responses,

¹⁰ See email from the Manufacturer on 6 November 2021, Question 7.

especially when the Manufacturer has a vested interest in distancing itself from the cause of the explosion.

IV. THE CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

23. In relation to the cause and circumstances of the Accident, we set out below Stars Engrg's position.

A. Whether the explosion occurred inside or outside the Mixer Machine

24. The fact that the initial event (i.e. the primary deflagration / explosion) was caused by pressure build-up within the Mixer Machine's oil jacket is common ground between the parties. However, the parties differ on whether the explosion occurred inside or outside the oil jacket. In this regard, Stars Engrg's position is that the explosion occurred inside the oil jacket.

25. Dr David Rose from Hawkins & Associates ("**Dr Rose**"), Stars Engrg's technical expert, opined that the explosion occurred inside the oil jacket. His view was that the explosion was caused by the accumulation and subsequent ignition of an oil mist inside the reservoir. The ignition of an oil mist would thereby generate sufficient pressure to rupture the oil jacket of

the machine's mixing chamber, project burning droplets of oil around the unit and result in a pressure wave sufficient to displace the internal walls, windows, doors, and roller shutters of units 32E and 32F. He also concluded that the ignition source was a heating element that caught fire (heating element number 2), which was damaged because of the fire that took place earlier in the morning of 24 February 2021.¹¹

26. On the other hand, Dr Salim from A*STAR, one of the AGC's technical experts, opined that the root cause of the Accident was likely due to the low amounts of heat transfer fluid used in the Mixer Machine, which led to the excessive heating of the heat transfer fluid and in turn a pressure build-up in the oil jacket. As a result, the heating jacket ruptured and released hot, pressurised heat transfer fluid into the environment that formed an ignited aerosol cloud which caused the chemical explosion outside of the oil jacket.¹²
27. It is vital to note that Dr Salim's views are premised on A*STAR's calculations of the peak overpressures arising from the chemical explosion, relying on an explosion efficiency of 1%. A*STAR then used the calculations to show that the damage caused by the Accident correlates to overpressure from a chemical explosion involving a heat transfer fluid

¹¹ Hawkins' Investigation into the Cause of the Explosion that Occurred at 32E Tuas Avenue 11, Singapore on 24 February 2021 dated 15 September 2021 ("**Hawkins' Report**") at [6.1.12]-[6.1.14]: ST-1; Transcript dated 6 October 2021, p 33 ln 24 to p 34 at ln 6 at ln 8.

¹² A*STAR's Report, p 8 at lns 1 to 7: S-283; Addendum to A*STAR's Accident Investigation Report dated 4 October 2021 ("**A*STAR's Addendum**"), p 3 at lns 13 to 17: S-283A.

volume of 40 litres.¹³ Accordingly, Dr Salim concluded that there would have been insufficient oxygen in the heating jacket for either complete or incomplete combustion to take place within the heating jacket that would generate sufficient overpressures to cause the damage observed after the Accident.¹⁴

28. Dr Salim's analysis is flawed in two aspects.
29. First, not all the oil had to be burned in order to raise the internal pressure sufficiently to rupture the oil jacket.
30. Second and more importantly, Dr Salim's reliance on an explosion efficiency of 1% is misplaced, as he had failed to take into consideration the first law of thermodynamics (i.e. energy cannot be created or destroyed). In a stationary closed system, the energy would be transferred by the combustion of the oil to the metal of the oil reservoir in the form of heat and pressure.
31. Consequently, this would increase the internal pressure of the closed system as the volume remained constant while the temperature would increase due to the combustion process. Following the first law of thermodynamics, the total amount of energy in the closed system must remain unchanged, with the reaction efficiency being 100%. Based on this

¹³ A*STAR's Report, p 39 at ln 13 to p 43 at ln 11: S-238.

¹⁴ A*STAR's Addendum, p 5 at lns 5 to 11; p 8 at lns 4 to 10: S-283A.

analysis, there would be sufficient oxygen in the oil jacket to ignite the oil mist and cause the explosion.

B. *There is no reliable evidence of secondary deflagrations*

32. Dr Salim also concluded that in addition to the primary deflagration that caused the Accident, up to three other flash fires followed after the initial event (i.e. secondary deflagrations).¹⁵ In his opinion, the secondary deflagrations were likely the result of the potato starch at the Workplace that were initially agitated and suspended by the overpressure from the primary deflagration to form a combustible dust cloud.¹⁶

33. In reaching this conclusion, Dr Salim relied only on the following:¹⁷

- a. The CCTV video footages retrieved from the neighbouring unit occupied by Alif Engineering Pte Ltd ("**Alif Engineering**"), which showed that there were up to three secondary deflagration events recorded by Cameras 8 and 7 at about 85 seconds, 125 seconds and 155 seconds after the primary deflagrations.¹⁸

¹⁵ A*STAR's Report, p 44 at Ins 3 to 6: S-283.

¹⁶ A*STAR's Report, p 61 at In 25 to p 62 at In 2: S-283.

¹⁷ Transcript dated 5 October 2021, p 117 at Ins 1 to 19.

¹⁸ A*STAR's Report, p 12 at In 16 to p 13 at In 3: S-283.

b. Analytical results showing that starch was present in trace quantities on the surfaces sampled in the immediate vicinity of the mixer.¹⁹

34. However, the above cannot conceivably be considered as reliable evidence of secondary deflagrations. We explain.

i. CCTV video footages

35. It was posited during the hearing that the three flashes caught on the CCTV footages were in fact dense smoke plumes instead of secondary deflagrations. To explain, the smoke plumes, which are essentially unburnt fuel, caused by primary deflagration had entered the neighbouring unit through the blast hole. These smoke plumes had burned and ignited when mixed with fresh air and were eventually caught by the CCTV footages as flashes.²⁰

36. We respectfully submit that this explanation ought to be preferred over Dr Salim's characterisation of the flashes as secondary deflagrations in view of the objective evidence that was captured on the CCTV footages.

¹⁹ A*STAR's Report, pp 48 to 51: S-283.

²⁰ Transcript dated 5 October 2021, p 120 at lns 13 to 24.

37. If Stars Engrg is right to say that the flashes were smoke plumes, this would explain why flashes number 1 and 2 were captured by camera 8, but not camera 7, and flash number 3 was captured by camera 7, but not camera 8. This is because the flash picked up by each individual camera would depend on the movement and location of the smoke plume, as well as the perspective of the camera.²¹
38. On the contrary, Dr Salim was unable to explain why two different cameras captured different flashes.²² Moreover, he also conceded that “*flash fires are potentially difficult to ascertain*” and he did not notice any physical signs of the secondary deflagrations.
39. Further and in any event, neither Dr Salim²³ nor Major Huang²⁴ sought to refute this proposition which was presented to them during the hearing. It therefore stands to reason that Dr Salim and Major Huang must have conceded this to be a plausible alternative explanation to the flashes caught on the CCTV footage. Indeed, Major Huang acknowledged that “[*this*] was *possible*”.²⁵
40. For completeness, there is no evidence to suggest that *other* secondary deflagrations occurred in Stars Engrg’s unit. On Major Huang’s account,

²¹ Transcript dated 5 October 2021, p 120 at Ins 13 to 24.

²² Transcript dated 5 October 2021, p 121 at Ins 2 to 3.

²³ Transcript dated 5 October 2021, p 121 at Ins 2 to 3.

²⁴ Transcript dated 7 October 2021, p 107 at Ins 10 to 18.

²⁵ Transcript dated 7 October 2021, p 107 at Ins 10 to 18.

these flashes occurred in Alif Engineering's unit only, and both cameras 7 and 8 did not capture any video footages within Stars Engrg's unit.²⁶

ii. Trace quantities of starch

41. The analytical results showing the presence of starch in trace quantities is unreliable for the following reasons.
42. First, it bears highlighting that Table 10 of A*STAR's Report reflected inconclusive FTIR analysis results and for most of the samples.²⁷ Accordingly, such results cannot be regarded as indicative of starch being present.
43. Second, even if starch was found to present, Dr Salim does not explain whether the starch was found in the fireclay. For instance, trace starch was present in the sample obtained from under the pallet at S/N 4 of Table 10. One explanation for this could be due to the workers dropping the fireclay from the platform (where the Mixer Machine was located) to the ground level / floor area,²⁸ which would have led to fine particles being ejected sideways and onto the floor. If the pallet was then placed on the floor thereafter, starch would inevitably be picked up by the pallet. Moreover, as the pallet was close to the epicentre of the primary explosion, the shock

²⁶ Transcript dated 7 October 2021, p 107 at ln 22 to p 108 at ln 5.

²⁷ A*STAR's Report, pp 49 to 50: S-283.

²⁸ Mr Hossain Jitu's Conditioned Stated at [47]: SS-9

wave generated by the explosion could have blasted some potato starch from the open bag next to the machine to under the pallet.

44. Third, Dr Salim failed to consider the high likelihood of the accident scene being contaminated and/or tampered with, particularly as the samples were collected more than three weeks after the Accident on 17 March 2021.²⁹ Apart from the initial response team, eight other site visits by various parties, including the MOM Investigation Team, the Inquiry Committee, the technical experts from Matcor Technology & Services Pte Ltd (“**Matcor**”) and A*STAR, and the representatives from Stars Engrg, were arranged. Nothing in the MOM’s Report on the Investigation Process dated 4 October 2021 (“**MOM Report**”) described how the Workplace was secured from contamination and/or movement of the debris by the individuals who visited the Workplace.
45. Indeed, it became apparent during Dr Rose’s testimony that the nuts securing heating element number 2 were removed after the Accident occurred and prior to his inspections of the Workplace on 15 March 2021 and 24 March 2021 under the MOM’s supervision.³⁰ It was also stated in the MOM’s Report that the two spanners initially found close to the additional heater during their first response on 24 February 2021 were subsequently moved and placed on the Mixer Machine, by the time Dr Rose inspected the Workplace.³¹ The removal of the nuts and the movement of

²⁹ MOM’s Report at [3.9]: S-289.

³⁰ Transcript dated 6 October 2021, p 45 at Ins 8 to 17.

³¹ MOM’s Report at [2.3.3]: S-289.

the spanners were presumably done without authorisation, given that even the MOM itself was unable to explain who removed the nuts and moved the spanners, and why they did so.³²

46. The security of the scene of the accident left much to be desired and Stars Engrg and/or its officers reserve their rights to ventilate the associated issues at the appropriate forum.

C. Other technical aspects of the Accident

47. Stars Engrg's position in relation to the other technical aspects of the Accident are as follows.
- a. The Mixer Machine was designed to operate as a closed system;
 - b. The low level of oil could not have caused the accident; and
 - c. There is no conclusive proof that the welding carried out by Mr Molla Mohammad Nasim ("**Mr Nasim**"), an employee of Stars Engrg, contributed to the explosion of the Mixer Machine.

48. We address each of them in turn.

³² Transcript dated 7 October 2021, p 69 at ln 9 to p 71 at ln 9.

i. The Mixer Machine was designed to operate as a closed system

49. It is undisputed between the parties that the oil jacket of the Mixer Machine operated as closed system at the material time, given that both the access port and the vent port were sealed.

50. That said, Dr Rose opined that the operation of the oil jacket as a closed system made no difference to the outcome of the explosion.³³ As the User Guide stated that the oil reservoir was designed to be operated as a sealed system and had an operating pressure of 0.2 MPa (2 bar) (i.e. twice the atmospheric pressure), it therefore follows that the oil jacket was designed to operate at a pressure higher than that of its surroundings, which includes a closed system.

51. Critically, Dr Rose gave evidence that the Mixer Machine was unable to withstand the pressure build-up arising from the ignition of the oil mist in any event, whether it was “*vented or unvented*”.³⁴ This is because the oil mist explosion would have generated “*about 10 to 20 bar[s] pressure*”,³⁵ which far exceeded the Mixer Machine’s operating pressure of 0.2 MPa (2 bar).

52. Moreover, he also pointed out that although the Contract of Sale dated 28 August 2019 indicated the thickness of the oil jacket to be 6 mm, the Mixer

³³ Hawkins’ Report at [7.6]: ST-1.

³⁴ Transcript dated 6 October 2021, p 54 at lns 15 to 16.

³⁵ Transcript dated 6 October 2021, p 54 at lns 11 to 14.

Machine failed to meet the standard claimed in the Contract of Sale as the wall of the oil reservoir was in fact only 4 mm thick. This considerably reduced the strength of the Mixer Machine such that it was more likely to only withstand an operating pressure of 0.17 MPa, rather than the 0.2 MPa stated in the User Guide, thereby rendering it more susceptible to failures.³⁶

ii. *The low level of oil could not have directly caused the accident*

53. While is undisputed between the parties that the Mixer Machine was operating with low levels oil, we respectfully highlight that this in itself could not have solely and directly caused the accident.

54. Pertinently, since June 2020, the employees of Stars Engrg had always operated the Mixer Machine with low levels of oil, and in some cases, as little as 40 litres of oil. Yet, up until February 2021, the operation of the Mixer Machine with low levels of oil neither caused a fire nor an explosion.

³⁶ Hawkins' Report at [6.3.6]: ST-1; Transcript dated 6 October 2021, p 56 at Ins 1 to 6.

iii. *There is no conclusive proof that the welding carried out by Mr Nasim, an employee of Stars Engrg, contributed to the explosion of the Mixer Machine*

55. Contrary to the position taken by the State's technical experts, the welding carried out by Mr Nasim, would not have contributed to explosion of the Mixer Machine. At the outset, we highlight that Mr Nasim was a certified welder.³⁷

56. It is pertinent to note that Mr Nasim had to carry out welding works in October 2020 only because there was a crack of about 3 mm long on the manufacturer's original welds³⁸ that had to be repaired. Indeed, Dr Shandro observed that "*the lack of root penetration with wide root opening (up to about 5.5 mm wide) at the repair welds of the oil jacket edges strongly suggested that the original welds at had ruptured open before repair weld and reinforcement plates were added*" (emphasis added).³⁹

57. While Dr Shandro goes on to note that the "*weld repairs... reduced the integrity and strength of the oil jacket*", there is simply no credible evidence to suggest that the weld repairs, even if they were of poor quality, contributed to the explosion of the Mixer Machine.

³⁷ Mr Nasim's Conditioned Statement dated 12 August 2021 ("**Mr Nasim's Conditioned Statement**"), MMN -1: SS-4, p 24

³⁸ Mr Nasim's Conditioned Statement, [48]-[53]: SS-4.

³⁹ Matcor's Technical Report dated 10 September 2021, p 26, Ins 23 to 25: S-279.

58. In any case, as the weakest points of the structure were the original weld lines, the oil reservoir would have failed at the original weld lines, regardless of whether the repair welds were eventually carried out as well as the quality of the repair welds. This is particularly so as the pressure created by the ignition of the oil mist would have far exceeded the design pressure of 0.2 MPa, thereby causing the original weld lines to rupture and fail.
59. Even on Dr Salim's case, the elevated temperature of the heat transfer fluid would cause a build-up in the pressure within the jacket of 6 to 103 barg,⁴⁰ clearly in excess of the Mixer Machine's heating jacket which was rated to operate at a pressure of less than 2 bar. It therefore follows that the original weld lines would inevitably to rupture abruptly as well.⁴¹

V. CONCLUSION

60. Stars Engrg deeply regrets this incident and remains committed in its continuous efforts to support the families of the deceased and the surviving employees who were injured since the Accident. This includes paying the families the salary of the deceased on a monthly basis since February 2021, as well as reimbursing the full medical expenses incurred by the injured workers.⁴²

⁴⁰ A*STAR's Report, p 30 at Ins 4 to 8: S-283.

⁴¹ A*STAR's Report, p 61 at Ins 7 to 13: S-283.

⁴² Transcript dated 27 September 2021, p 140 at ln 12 to p 141 at ln 14.

61. What is indisputable and amply clear is that the Accident would have been avoided if the workers had followed Mr Chua's instructions to stop work and wait for him at the Workplace after the initial fire in the morning of 24 February 2021.⁴³ As the AGC had adopted an adversarial approach to the Inquiry to pin blame on Stars Engrg and/or its officers, the State Counsel had advanced a case theory that the workers were placed under pressure to complete the production for the day, and hence decided to ignore Mr Chua's instructions. There is no evidence to support the AGC's case theory. More importantly, the AGC's case theory acknowledges the truth that Mr Chua had asked the workers to cease production and not operate the Mixer Machine.

Dated this 10th day of December 2021



SOLICITORS FOR THE INTERESTED PARTY
Rajah & Tann Singapore LLP

⁴³ Transcript dated 27 September 2021, p 61 at lns 9 to 24.

Annex A

S/N	Query	The Manufacturer's Response	Objective Evidence
A. Certification of the Manufacturer and the Mixer Machine			
1.	<p>Stars Engrg's Clarification Question for Query (2): ... Assuming the machine is a customised product, would the machine still have to meet the CE and ISO standards / certifications as stated by the manufacturer when provided to the customer? If so, did this kneader machine provided to Stars meet the CE and ISO standards/certification?</p>	<p>... Our order contract with the customer does not mention CE and ISO standards/certifications.</p>	<p>The printout from Alibaba.com showing information on the Mixer Machine and the Manufacturer at CXD-21 ("Printout") indicates the following:</p> <ul style="list-style-type: none"> • It is stated under the "Overview" section that the machine has the certification of "ce iso".¹ • The "Certifications" section shows various certifications obtained by the Manufacturer.² • It is stated under the "FAQ" section that the Manufacturer had passed the ISO9001 certification, and most of their products had passed the CE certification.³

¹ Mr Chua Conditioned Statement dated 27 August 2021 ("**Mr Chua's Conditioned Statement**"), p 233: SS-6.

² Mr Chua's Conditioned Statement, p 242: SS-6.

³ Mr Chua's Conditioned Statement, p 245: SS-6.

S/N	Query	The Manufacturer's Response	Objective Evidence
B. The Manufacturer's reference to the Mixer Machine as an "atmospheric machine"			
2.	Query (5): What would happen if the thermal jacket was operated beyond 0.2 MPa?	... This model is an atmospheric machine	<p>None of the documents provided by the Manufacturer states that the Mixer Machine is an "atmospheric machine".</p> <p>If anything, the documents suggest that the Mixer Machine operates under a pressurised system.</p> <ul style="list-style-type: none"> The Printout at CXD-21 states "[the machine is] designed for pressure, vacuum or inert gas operation" as one of the Mixer Machine's main features.⁴ The User Guide for the Mixer Machine ("User Guide") at CXD-25 states "pressure type" as one of the machine's technical parameters, and a pressure level of 0.45 MPa as its technical specification.⁵
3.	Stars Engrg's Clarification Question for Query (5): What does "atmospheric machine" mean? Was the customer provided information about the model of the machine being an "atmospheric machine"?	Atmospheric pressure machine means that no part of the machine can produce pressure during the working process. The fuel filler port of this machine is an open design, which will not generate pressure. The picture has been provided to stars company.	
C. The Manufacturer's assertion that all the openings, in particular port "X" must be kept open			
4.	Query (11): There are 3 pipe/port openings on the thermal jacket (see markings "X", "Y" and "Z" in the two photos attached below). What are each of the openings designed to be used for?	"X" is the heat-conducting oil filling and exhaust port, and the top of the "X" is equipped with a funnel (picture attached). Make sure that the user blocks the "X" privately, without permission; the Y port is the exhaust port while filling the oil,	None of the documents provided by the Manufacturer, in particular the User Guide at CXD-25 , state that port "X" was meant to be open, and that its function was to

⁴ Mr Chua's Conditioned Statement, p 238: SS-6.

⁵ Mr Chua's Conditioned Statement, p 271: SS-6.

S/N	Query	The Manufacturer's Response	Objective Evidence
		in order to fill the oil smoothly, "Z" is the oil drain port.	
5.	MOM's Clarification Question for Query (11): Please clarify what you mean by "Make sure that the user blocks the "X" privately, without permission".	The X port is an open design, and this place is open when the machine is delivered. The picture you provided shows that port X is blocked. Keda did not provide any information to ask the customer to block the X port.	ensure that the operating pressure inside the Mixer Machine does not exceed 0.2 MPa. These are also not evident from Item 2 under Section 8 of the User Guide. Importantly, Section Ten of the User Guide at CXD-25 states that " <i>when refueling, you need to <u>open</u> one side vent hole and add it to half the height of the cylinder</i> " (emphasis added). ⁶ This therefore contemplates the closing of the vent holes, especially since the Mixer Machine was delivered with port "X" open.
6.	Query (12): Are any of the openings mentioned at question 11 above (i.e. "X", "Y" or "Z") meant to be closed when the kneader machine is in operation?	"X" needs to be kept in its original state when working, "Y" and "Z" are closed (refer to the photos in Article 11).	
7.	Query (13): Is the kneader machine / thermal jacket intended to operate as a closed system? If yes, how is the user informed of this?	No, it isn't.	
8.	Stars Engrg's Clarification Question for Query (13): Was there any indication in the User Guide or any written correspondence with the customer, Stars, that the machine was intended to operate as an open system? If yes, please provide us with the reference and supporting documents.	The pictures and videos provided by Keda to stars can explain this, and they are clearly shown as open.	
9.	IC's Clarification Question for Query (13): Was Stars informed that the kneader machine / thermal jacket was intended to operate with "X" in an open state?	Yes. Because the state of the machine is correct and normal when the machine is delivered, the pictures sent to the customer also shows that the X port is open. It can also be found and verified in item Eight- 2 of the 4 th page of the USER'S GUIDE. "2. <i>This system uses heat conduction oil electric heating tube for heating, which has high requirements for the quality and material of heat conduction oil. It is recommended to use HD series high</i>	

⁶ Mr Chua's Conditioned Statement, p 271: SS-6.

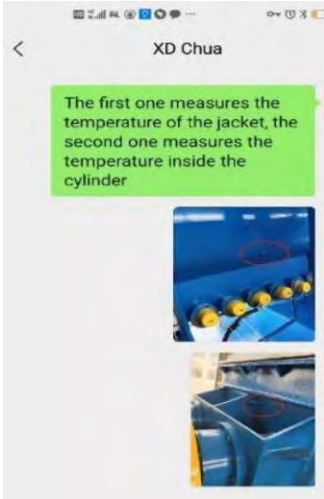
S/N	Query	The Manufacturer's Response	Objective Evidence
		<p><i>temperature heat conduction oil. Generally, the heat conduction oil should be preheated before being injected into the jacket of the mixing tank to facilitate the evaporation of the moisture of the oil. An oil vapor vent is provided at the highest point behind the machine, and the oil vapor vent is directly connected to the vent Pool. Care should be taken in the heating process, and avoid using hands to detect whether the pipes and the outside of the mixing tank are heated. It's easy to get burned."</i></p>	
10.	<p>Query (14): Does the reference at page 4 of the User Guide, under "Design of thermal jacket", to "Working pressure of: \leq 0.2 Mpa" mean?</p>	<p>No, it cannot be closed. Pressure will be generated in the case of poor exhaust in the jacket, and the pressure that the equipment can withstand does not exceed 0.2Mpa.</p>	
11.	<p>Query (15): How is the user supposed to ensure that the working pressure within the thermal jacket remains \leq0.2 Mpa during operation.</p>	<p>"X" must be kept connection to the outside air and unblocked.</p>	
12.	<p>Stars Engrg's Clarification Question for Query (14): With reference to your answer to Query 14 above that "the pressure that the equipment can withstand does not exceed 0.2Mpa", please advise how the user is able to know that the exhaust is poor and the pressure is building up in the jacket? Please advise if there is any safety feature provided in the machine to prevent such a situation?</p>	<p>According to design of Keda, if the exhaust is poor or the pressure builds up, there will be gas volatilization at the funnel.</p> <p>The machine is provided with a related safety device, which is the funnel at the X port to keep the jacket unblocked. The description or explanation can be found in item eight-2, page 4 of the USER'S GUIDE.</p>	
13.	<p>Query (22): At page 5 of the User Manual it is stated: "<i>When refueling, you need to open one side vent hold and add it to half</i></p>	<p>"Open one side vent hole" means opening the "Y", which is used to remove the air in the</p>	<p>The function of "Y" is not explained in the User Guide at CXD-25 and the labelled diagram in the</p>

S/N	Query	The Manufacturer's Response	Objective Evidence
	<i>the height of the cylinder</i> ". What does "open one side vent hole" and "half the hight of the cylinder" mean?	cylinder when filling oil, and used to check the volume, needs to be closed after operation...	Printout at CXD-21 does not show "Y" as the "side vent hole". ⁷
D. The Manufacturer's assertion that HD320-350# high temperature heat transfer oil should be used inside the thermal jacket			
14.	Query (18): What liquid(s) are meant to be used inside the thermal jacket? What liquid does Laizhou Keda recommend be used in the thermal jacket, and why?	... Keda recommends to refer to HD320-350# high temperature heat transfer oil in the USER'S GUIDE (and we have introduced the characteristics and uses of the hat transfer oil to users by WeChat), because of the requirements of working temperature, it is recommended to choose.	The Manufacturer had indicated that water can also be used inside the thermal jacket: <ul style="list-style-type: none"> • Section Four of the User Guide at CXD-25 states "Hot Water in Jacket" as one method of heating.⁸ • In Sherry's messages to Chua at CXD-22, she stated that "<i>if the temperature in the jacket is lower than 100 degrees, it can be filled with water, but in this case, the heating rod will be easily damaged</i>" (IM#147).⁹


⁷ Mr Chua's Conditioned Statement, p 234: SS-6.

⁸ Mr Chua's Conditioned Statement, p 271: SS-6.

⁹ Mr Chua's Conditioned Statement, p 260: SS-6.

S/N	Query	The Manufacturer's Response	Objective Evidence
E. The Manufacturer's assertion that instructions on how to use the temperature sensors were given to Stars			
15.	Query (30)(i): Were instructions on how to use the temperature sensors given to Stars?	<p>Yes, Keda has instructions for material temperature and oil temperature on the electric control cabinet, and also informs customers how to use it through online communication.</p> 	<p>The veracity of the Manufacturer's evidence is questionable, particularly as the messages that they purportedly sent to Mr Chua on 12 June 2020 at 14:25 and 14:42 are absent from the same set of WeChat messages extracted by the Cyber Crime Response Team (Jurong Division, SPF) at CXD-22.¹⁰ In fact, our client denies receiving these messages.</p> <p>Moreover, it is also telling that the Manufacturer failed to provide a copy of all its communications with Stars / Mr Chua Xing Da despite MOM's request, and did not explain why they failed to do so.</p>
16.	MOM's Clarification Question for Query (30)(i)(ii): Can Laizhou Keda indicate when the online communication response shown in the screenshot was provided to Mr Chua Xing Da and how was this provided?	It was provided in June, 2020, through the WeChat.	

¹⁰ Mr Chua's Conditioned Statement, p 320: SS-6.

S/N	Query	The Manufacturer's Response	Objective Evidence
			
17.	<p>MOM's Clarification Question for Query (30)(i)(iii): According to Mr Chua Xing Da, he had called you to ask where the temperature sensors should be placed in the kneader</p>	<p>It is not correct. Mr CHUA's question has been clearly answered, as shown in the above answer.</p>	<p>Paragraph 83 of Mr Chua's Conditioned Statement at SS-6 states, "I had once asked Sherry</p>

S/N	Query	The Manufacturer's Response	Objective Evidence
	machine, but you did not provide him with any instructions and instead referred him to the User Guide. Could you please confirm if this account of your conversation with Mr Chua Xing Da is accurate?		<i>via WeChat on 12 June 2020 at 12:45 pm "... which location can I put the thermocouple", as shown in the WeChat messages between Sherry and me from 12 June 2200 to 24 February 2021, which were extracted from my mobile phone by the CCRT, annexed as CXD-40 (IM#54). However, she did not reply. When I called Sherry via either WhatsApp or WeChat, she told me to refer to the User Guide. However, the User Guide did not specify where the temperature sensors were to be placed."</i> ¹¹
18.	IC's Clarification Question for Query (30)(i): Did Laizhou Keda advise Mr Chua Xing Da on how the kneader machine worked such that it would turn off the heaters automatically after reaching a certain temperature?	Laizhou Keda provided the guidance in the telephone consultation.	Based on Mr Chua's recollection, there was no such telephone conversation and/or telephone consultation.
F. The Manufacturer's denial that Stars Engrg had never contacted them regarding the repairs to the Mixer Machine			
19.	Query (43): Has Stars contacted you before regarding repairs to the kneader machine?	They never contacted the problem of repairing the kneader. But they contacted to buy a new machine again on February 12, 2021, and prepared to place another order with us.	Stars Engrg and/or its officers do not accept the Manufacturer's position and reserve their right to make full arguments at the appropriate juncture and any subsequent forum.
20.	MOM's Clarification Question for Query (43): According to Mr Chua Xing Da, you had said in response that you could not help and that he should have purchased a better machine	It is very inaccurate. I have never received such a call, and I did not elaborate on the response to such a statement. This is totally inconsistent with the facts.	In any case, Mr Chua's position has been set out at paragraphs

¹¹ Mr Chua's Conditioned Statement, p 23: SS-6.

S/N	Query	The Manufacturer's Response	Objective Evidence
	instead. Could you please confirm if this account of your conversation with Mr Chua Xing Da is accurate?		208 and 209 of his Conditioned Statement. ¹²
G. The Manufacturer's assertion that they provided technical guidance to their customers			
21.	Query (44): Apart from the User Guide, were any other operating instructions on how to use the machine given to Stars Engrg?	Before shipment, we provided the test video and completed pictures of the machine. After shipment, we provide technical guidance to customers through telephone and online service, including preparations before starting the machine, precautions, etc., and asked the customer if they have any questions about the machine, looking forward to customer feedback.	It is not apparent from the extracted messages at CXD-22 and CXD-40 that the Manufacturer provided technical guidance on preparations before starting the machine and precautions. From the messages at CXD-22 , apart from checking whether Mr Chua had any questions (IM#93), ¹³ as well as whether he had started using the machine and had any problems (IM#105), ¹⁴ the Manufacturer did not voluntarily provide any guidance, and only responded to Mr Chua's questions (see IM#110-138 and IM#145-166) ¹⁵
22.	MOM's Clarification Question for Query (44): May we have a copy of the test video? Please also indicate when the test video was provided to Stars, and how it was provided.	Sure, enclosed the video in this email. By WhatsApp and Email.	Mr Chua is unable to recall whether he had received the video titled " <i>testing video</i> ". In any case, the video does not provide any guidance on how the Mixer Machine should be

¹² Mr Chua's Conditioned Statement, pp 60 to 61: SS-6.

¹³ Mr Chua's Conditioned Statement, p 252: SS-6.

¹⁴ Mr Chua's Conditioned Statement, p 253: SS-6.

¹⁵ Mr Chua's Conditioned Statement, pp 254 to 258, 260 to 264: SS-6.

S/N	Query	The Manufacturer's Response	Objective Evidence
			operated, in particular where the thermocouple should be placed.

**ANNEX L – EXTRACTS FROM THE WORKPLACE SAFETY AND HEALTH
ACT**

Duty of occupier of workplace

11. It shall be the duty of every occupier of any workplace to take, so far as is reasonably practicable, such measures to ensure that —

- (a) the workplace;
- (b) all means of access to or egress from the workplace; and
- (c) any machinery, equipment, plant, article or substance kept on the workplace, are safe and without risks to health to every person within those premises, whether or not the person is at work or is an employee of the occupier.

Duties of employers

12—(1) It shall be the duty of every employer to take, so far as is reasonably practicable, such measures as are necessary to ensure the safety and health of his employees at work.

(2) It shall be the duty of every employer to take, so far as is reasonably practicable, such measures as are necessary to ensure the safety and health of persons (not being his employees) who may be affected by any undertaking carried on by him in the workplace.

(3) For the purposes of subsection (1), the measures necessary to ensure the safety and health of persons at work include —

- (a) providing and maintaining for those persons a work environment which is safe, without risk to health, and adequate as regards facilities and arrangements for their welfare at work;
- (b) ensuring that adequate safety measures are taken in respect of any machinery, equipment, plant, article or process used by those persons;
- (c) ensuring that those persons are not exposed to hazards arising out of the arrangement, disposal, manipulation, organisation, processing, storage, transport, working or use of things —
 - (i) in their workplace; or
 - (ii) near their workplace and under the control of the employer;
- (d) developing and implementing procedures for dealing with emergencies that may arise while those persons are at work; and
- (e) ensuring that those persons at work have adequate instruction, information, training and supervision as is necessary for them to perform their work.

(4) Every employer shall, where required by the regulations, give to persons (not being his employees) the prescribed information about such aspects of the way in which he conducts his undertaking as might affect their safety or health while those persons are at his workplace.

Duties of principals

14. (1) Subject to subsection (2), it shall be the duty of every principal to take, so far as is reasonably practicable, such measures as are necessary to ensure the safety and health of —

- (a) any contractor engaged by the principal when at work;

(b) any direct or indirect subcontractor engaged by such contractor when at work; and

(c) any employee employed by such contractor or subcontractor when at work.

(2) The duty imposed on the principal in subsection (1) shall only apply where the contractor, subcontractor or employee referred to in that subsection is working under the direction of the principal as to the manner in which the work is carried out.

(3) It shall be the duty of every principal to take, so far as is reasonably practicable, such measures as are necessary to ensure the safety and health of persons (other than a person referred to in subsection (1)(a), (b) or (c) working under the principal's direction) who may be affected by any undertaking carried on by him in the workplace.

(4) For the purposes of subsection (1), the measures necessary to ensure the safety and health of persons at work include —

(a) providing and maintaining for those persons a work environment which is safe, without risk to health, and adequate as regards facilities and arrangements for their welfare at work;

(b) ensuring that adequate safety measures are taken in respect of any machinery, equipment, plant, article or process used by those persons;

(c) ensuring that those persons are not exposed to hazards arising out of the arrangement, disposal, manipulation, organisation, processing, storage, transport, working or use of things —

(i) in their workplace; or

(ii) near their workplace and under the control of the principal;

(d) developing and implementing procedures for dealing with emergencies that may arise while those persons are at work; and

(e) ensuring that those persons at work have adequate instruction, information, training and supervision as is necessary for them to perform their work.

(5) Every principal shall, where required by the regulations, give to persons (other than a person referred to in subsection (1)(a), (b) or (c) working under the principal's direction) the prescribed information about such aspects of the way in which he conducts his undertaking as might affect their safety or health while those persons are at his workplace.

Persons at Work

15.—(3A) Any person at work who, without reasonable cause, does any negligent act which endangers the safety or health of himself or others shall be guilty of an offence and shall be liable on conviction to a fine not exceeding \$30,000 or to imprisonment for a term not exceeding 2 years or to both.

Duties of manufacturers and suppliers of machinery, equipment or hazardous substances used at work

16.—(1) Subject to this section, it shall be the duty of any person who manufactures or supplies any machinery, equipment or hazardous substance for use at work to ensure, so far as is reasonably practicable

(a) that the following information about the safe use of the machinery, equipment or hazardous substance is available to any person to whom the machinery, equipment or hazardous substance is supplied for use at work:

(i) the precautions (if any) to be taken for the proper use and maintenance of the machinery, equipment or hazardous substance;

(ii) the health hazards (if any) associated with the machinery, equipment or hazardous substance; and

(iii) the information relating to and the results of any examinations or tests of the machinery, equipment or hazardous substance under paragraph (c) that are relevant to its safe use;

(b) that the machinery, equipment or hazardous substance is safe, and without risk to health, when properly used;

(c) that the machinery, equipment or hazardous substance is examined and tested so as to comply with the obligation imposed by paragraph (b).

(2) The duties imposed on any person specified in subsection (1) shall

(a) apply only if the machinery, equipment or hazardous substance is manufactured or supplied in the course of trade, business, profession or undertaking carried on by the person, whether for profit or not;

(b) apply whether or not the machinery, equipment or hazardous substance is exclusively manufactured or supplied for use by persons at work; and

(c) extend to the supply of the machinery, equipment or hazardous substance by way of sale, transfer, lease or hire and whether as principal or agent, and to the supply of the machinery, equipment or hazardous substance to a person for the purpose of supply to others.

(3) The duties imposed on any person specified in subsection (1) shall not apply to a person by reason only that the person supplies the machinery or equipment under a hire-purchase agreement, conditional sale agreement or credit-sale agreement to another (referred to in this section as the customer) in the course of a business of financing the acquisition of the machinery or equipment by the customer from others.

(4) Where a person (referred to in this subsection as the ostensible supplier) supplies any machinery or equipment for use at work to a customer under a hire-purchase agreement, conditional sale agreement or credit-sale agreement, and the ostensible supplier —

(a) carries on the business of financing the acquisition of goods by others by means of such agreements; and

(b) in the course of that business acquired his interest in the machinery or equipment supplied to the customer as a means of financing its acquisition by the customer from a third person (referred to in this subsection as the effective supplier),

the effective supplier shall be treated for the purposes of this section as supplying the machinery or equipment to the customer instead of the ostensible supplier, and any duty imposed by subsection (1) on a supplier shall accordingly apply to the effective supplier, and not to the ostensible supplier.

(5) Where a person designs, manufactures or supplies any machinery, equipment or hazardous substance for use at work and does so for or to another on the basis of a written undertaking by that other to take specified steps sufficient to ensure, so far as is reasonably practicable, that the machinery, equipment or hazardous substance will be safe and without risk to health when properly used, the undertaking shall have the effect of relieving the first-mentioned person from the duty imposed by subsection (1)(b) to such extent as is reasonable having regard to the terms of the undertaking.

(6) Any person required under subsection (1)(c) to ensure that any machinery, equipment or hazardous substance is examined and tested so as to comply with the obligation imposed by subsection (1)(b) shall be regarded as having complied with subsection (1)(c) to the extent that —

(a) the examination or test has already been carried out otherwise than by, or on behalf of, the person; and

(b) it is reasonable for the person to rely on that examination or test.

(7) For the purposes of this section, an absence of safety, or a risk to health, shall be disregarded in so far as the case in or in relation to which it would arise is shown to be one the occurrence of which could not reasonably be foreseen.

(8) In this section, “supplier”, in relation to any machinery, equipment or hazardous substance, does not include a manufacturer of those items when supplying, but includes an importer when supplying those items.

(9) This section shall apply only to machinery, equipment or hazardous substances specified in the Fifth Schedule.

Duties of persons who erect, install or modify machinery or equipment and persons in control of machinery for use at work

17.—(1) It shall be the duty of any person who erects, installs or modifies any machinery or equipment for use at work to ensure, so far as is reasonably practicable, that the machinery or equipment is erected, installed or modified in such a manner that it is safe, and without risk to health, when properly used.

(2) The duty imposed on a person erecting, installing or modifying any machinery or equipment under subsection (1) shall apply only if the machinery or equipment is erected, installed or modified in the course of the person’s trade, business, profession or undertaking.

(3) Any person required under subsection (1) to ensure that any machinery or equipment is erected, installed or modified in such a manner that it is safe, and without risk to health, when properly used shall be regarded as having complied with that subsection to the extent that —

(a) the person ensured, so far as is reasonably practicable, that the erection, installation or modification was in accordance with the information supplied by the designer, manufacturer or supplier of the machinery or equipment regarding its erection, installation or modification; and

(b) it is reasonable for the person to rely on that information.

(4) Where any machinery moved by mechanical power is used in any workplace, then notwithstanding anything in this Act, it shall be the duty of the owner of the machinery to ensure —

(a) so far as is reasonably practicable, that the machinery is maintained in a safe condition; and

(b) that the precautions (if any) to be taken for the safe use of the machinery and the health hazards (if any) associated with the machinery are available to any person using the machinery.

(5) Where the owner of any machinery moved by mechanical power has entered into a contract of hire or lease with a hirer or lessee, the duty imposed under subsection (4) shall apply to the hirer or lessee of the machinery instead of the owner.

(6) Where the owner, hirer or lessee of any machinery moved by mechanical power has entered into a contract with another person to maintain the machinery, the duty under subsection (4)(a) shall apply to that other person instead of the owner, hirer or lessee of the machinery.

(7) Subsections (1), (2) and (3) shall apply only to machinery or equipment specified in Part I of the Fifth Schedule.

Offences by bodies corporate, etc.

48.— (1) Where an offence under this Act has been committed by a body corporate, an officer of the body corporate shall be guilty of the offence and shall be liable to be proceeded against and punished accordingly unless he proves that —

(a) the offence was committed without his consent or connivance; and

(b) he had exercised all such diligence to prevent the commission of the offence as he ought to have exercised having regard to the nature of his functions in that capacity and to all the circumstances.

FIFTH SCHEDULE

MACHINERY, EQUIPMENT OR HAZARDOUS SUBSTANCES

PART I

MACHINERY AND EQUIPMENT

1. Scaffolds and any materials or components used to erect them
2. All lifting equipment
3. Forklifts
4. Power presses
5. Bar-benders
6. Any equipment or piping intended for operation under pressure, including all statutory pressure vessels
7. Any equipment or piping intended to contain corrosive, toxic or flammable substances
8. Welding equipment, including any accessory, apparatus or fitting necessary to enable its use
9. Materials or components used for the construction of support structures
10. Explosive powered tools

11. Equipment used for abrasive blasting, including any accessory, apparatus or fitting necessary to enable its use and operation.

PART II

HAZARDOUS SUBSTANCES

- 1. Corrosive substances*
- 2. Flammable substances*
- 3. Explosives*
- 4. Oxidising substances*
- 5. Pyrophoric substances*
- 6. Gases under pressure*
- 7. Organic peroxides*
- 8. Self heating substances*
- 9. Self-reactive substances*
- 10. Substances which in contact with water, emit flammable gases*
- 11. Toxic substances*
- 12. Mutagens*
- 13. Carcinogens*
- 14. Teratogens*
- 15. Sensitizers*
- 16. Irritants*
- 17. Substances hazardous to aquatic environment.*

**ANNEX M – EXTRACTS FROM THE WORKPLACE SAFETY AND
HEALTH (RISK MANAGEMENT) REGULATIONS**

Risk assessment

3.—(1) In every workplace, the employer, self-employed person and principal shall conduct a risk assessment in relation to the safety and health risks posed to any person who may be affected by his undertaking in the workplace.

(2) The Commissioner may determine the manner in which the risk assessment referred to in paragraph (1) is to be conducted.

Elimination and control of risk

4.—(1) In every workplace, the employer, self-employed person and principal shall take all reasonably practicable steps to eliminate any foreseeable risk to any person who may be affected by his undertaking in the workplace.

(2) Where it is not reasonably practicable to eliminate the risk referred to in paragraph (1), the employer, self-employed person or principal shall implement —

(a) such reasonably practicable measures to minimise the risk; and

(b) such safe work procedures to control the risk.

(3) The measures referred to in paragraph (2)(a) may include all or any of the following:

(a) substitution;

(b) engineering control;

(c) administrative control;

(d) provision and use of suitable personal protective equipment.

(4) The employer, self-employed person or principal shall specify the roles and responsibilities of persons involved in the implementation of any measure or safe work procedure referred to in paragraph (2).

(5) In this regulation —

“administrative control” means the implementation of any administrative requirement which includes a permit-to-work system;

“engineering control” —

(a) means the application of any scientific principle for the control of any workplace hazard; and

(b) includes the application of physical means or measures to any work process, equipment or the work environment such as the installation of any barrier, enclosure, guarding, interlock or ventilation system;

“safe work procedure” means any procedure for carrying out work safely, and includes any procedure which is to be taken to protect the safety and health of persons in the event of an emergency;

“substitution” means the replacement of any hazardous material, process, operation, equipment or device with less hazardous ones.

**ANNEX N - EXTRACTS FROM THE WORKPLACE SAFETY AND HEALTH
(GENERAL PROVISIONS) REGULATIONS**

Part III – General Provisions Relating to Safety

Hoists and lifts

- 19.(1) No hoist or lift shall be used in a workplace unless an authorised examiner has —
- (a) tested and examined the hoist or lift after its installation; and
 - (b) issued and signed a certificate of test and examination, specifying the safe working load of the hoist or lift.
- (2) The certificate of test and examination referred to in paragraph (1)(b) shall be kept available for inspection.
- (3) Subject to paragraph (10)(c), every hoist or lift used in a workplace shall be thoroughly examined by an authorised examiner at least once every 6 months or at such other intervals as the Commissioner may determine.

Lifting gears

- 20.(1) No lifting gear of whatever material shall be used in a workplace unless an authorised examiner has —
- (a) tested and examined the lifting gear; and
 - (b) issued and signed a certificate of test and examination, specifying the safe working load of the lifting gear.
- (2) The certificate of test and examination referred to in paragraph (1)(b) shall be kept available for inspection.
- (3) Every lifting gear used in a workplace shall be thoroughly examined by an authorised examiner at least once every year or at such other intervals as the Commissioner may determine. Electric generator, motor, transmission machinery, etc.

Lifting appliances and lifting machines

21. (1) No lifting appliance or lifting machine shall be used unless an authorised examiner has —
- (a) tested and examined the lifting appliance or lifting machine; and
 - (b) issued and signed a certificate of test and examination, specifying the safe working load of the lifting appliance or lifting machine.
- (2) The certificate of test and examination referred to in paragraph (1)(b) shall be kept available for inspection.
- (3) Every lifting appliance and lifting machine shall be thoroughly examined by an authorised examiner at least once every year or at such other intervals as the Commissioner may determine.

Precautions with regard to explosive or flammable dust, gas, vapour or substance

26. —(1) Where any process in a plant used in a workplace gives rise to dust, gas, vapour or substance that may escape into any place of work and the dust, gas, vapour or substance that may escape is of such a character and is to such an extent as to be liable to explode on ignition —
- (a) all reasonably practicable steps shall be taken to prevent such an explosion —

- (i) by enclosure of the plant used in the process;
 - (ii) by removal or prevention of accumulation of the dust, gas, vapour or substance;
 - (iii) by exclusion or effective enclosure of possible sources of ignition; or
 - (iv) by the use of suitable flame-proof equipment; and
- (b) unless the plant in which the process is carried out is so constructed as to withstand the pressure likely to be produced by any such explosion, all reasonably practicable steps shall be taken to restrict the spread and effects of such an explosion by the provision of chokes, baffles and vents, or other equally effective appliances in the plant.

(2) Where any part of a plant in a workplace contains any explosive or flammable gas or vapour under pressure greater than atmospheric pressure, that part shall not be opened, unless it is positively isolated, depressurised and vented to a safe location, and where necessary, purged to remove any residual gas or vapour.

(3) No plant, tank or vessel in a workplace that contains, or has contained, any explosive or flammable substance shall be subjected to —

- (a) any welding, brazing or soldering operation;
- (b) any cutting operation which involves the application of heat; or
- (c) any operation involving the application of heat for the purpose of taking apart or removing the plant, tank or vessel or any part of it, until all reasonably practicable steps have been taken to remove the substance and any fumes, gas or vapour arising from it, or to render the substance and fumes non-explosive and non-flammable.

Conditions before steam boiler, steam receiver, air receiver or refrigerating plant pressure receiver may be used

27. (1) *Subject to paragraph (2), it shall be the duty of the owner of any steam boiler, steam receiver, air receiver or refrigerating plant pressure receiver (referred to in this regulation as relevant equipment) who intends to put the relevant equipment into use in a workplace to —*

- (a) obtain, in such form and manner as may be determined by the Commissioner, the approval of the Commissioner to use the relevant equipment;*
- (b) ensure that such examination and test by an authorised examiner as may be specified by the Commissioner has been satisfactorily carried out;*
- (c) obtain from the authorised examiner a report of the examination and test referred to in sub-paragraph (b), specifying the safe working pressure of the relevant equipment and stating the nature of the tests to which the relevant equipment and its fittings have been submitted;*
- (d) keep the report referred to in sub-paragraph (c) available for inspection; and*
- (e) mark the relevant equipment so as to enable it to be identified as the relevant equipment to which the report refers.*

Steam boilers

28. (6) Every —

- (a) steam boiler referred to in paragraph (5), including all its fittings and attachments, shall be thoroughly examined by an authorised examiner at least once every 2 years and also after any extensive repair; and*
- (b) surface of the external shell of a steam boiler referred to in paragraph (5) shall be examined by an authorised examiner at least once every 6 years, and for the purpose of such examination, the insulation on the shell shall be removed completely.*

Steam receivers

29. (6) Subject to paragraph (7) and regulation 31A, every steam receiver shall be examined by an authorised examiner —

- (a) at least once every 2 years; and*
- (b) after any extensive repairs.*

Air receivers

31. (5) Subject to paragraph (6) and regulation 31A, every air receiver shall be —

- (a) thoroughly cleaned; and*
- (b) examined by an authorised examiner at least once every 2 years.*

Warning labels

42. It shall be the duty of the occupier of a workplace in which there is any container of hazardous substances to ensure that, so far as reasonably practicable, every such container is affixed with one or more warning labels that conform with —

- (a) any Singapore Standard relating to the classification and labelling of hazardous substances;*
- or*
- (b) such other standards, codes of practice or guidance relating to the classification and labelling of hazardous substances as is issued or approved by the Council.*

Safety data sheet

43. —(1) Where any hazardous substance is used, handled or stored in a workplace, it shall be the duty of the occupier of the workplace to —

- (a) obtain a safety data sheet of the substance;*
- (b) assess the information in the safety data sheet and take precautionary measures to ensure the safe use of the substance; and*
- (c) make available the safety data sheet to all persons at work in the workplace who are liable to be exposed to the substance.*

(2) Where any hazardous substance is sold to any person for use in a workplace, it shall be the duty of the seller or any agent of the seller who caused or procured the sale to provide the buyer with a safety data sheet for the substance that —

- (a) gives accurate and adequate information on the substance; and
- (b) conforms with any Singapore Standard relating to safety data sheets or such other standards, codes of practice or guidance as is issued or approved by the Council.

“hazardous substance” means any hazardous substance specified in Part II of the Fifth Schedule to the Act

ANNEX O – EXTRACTS OF COMBUSTIBLE DUST-RELATED LEGISLATION

Singapore Civil Defence Force

Singapore Civil Defence Force (SCDF) implements licensing controls over petroleum and flammable materials (P&FM) that are listed under the Fire Safety Act and the Fire Safety (Petroleum & Flammable Materials) Regulations. Companies are required to apply for a P&FM storage licence, which is renewable once every year. This is to help ensure fire safety compliance for the storage of P&FM, minimize fire safety risk through safe handling of these substances and ensure that there are proper emergency response procedures put in place. The current list of petroleum and flammable materials included metal powders such as aluminum, magnesium and zinc, which are combustible powders.

For new built and buildings where works carried out will affect the fire safety works within the building, building plan approval has to be sought from SCDF and the fire safety measures are required to comply with the Fire Code requirements. This will also apply to buildings or premises that may use or store combustible powders.

Singapore Food Agency

Singapore Food Agency (SFA) administers the Sale of Food Act and the Singapore Food Regulations to ensure that the food made available for sale in Singapore are safe for consumption. Part of SFA's regime involves the implementation of controls on commercial food imports that enter Singapore including process food some of which are combustible dusts. Examples of processed food include:

- Infant formula
- Milk products (eg. cheese, milk powder, etc.)
- Biscuits
- Flour
- Cereals
- Coffee powder

There are labelling requirements for pre-packed food and the labels aim to provide consumers with basic information of the product such as the source, nature and contents, quantity and quality. Under the Food Regulations, these labels need to include details such as the ingredients used.

Ministry of Manpower

Under the Workplace Safety and Health Act and its subsidiary legislations, MOM ensures that workers' safety and health is safeguarded in workplaces. Currently, there are provisions under the WSH (General Provisions) Regulations on precautions and measures to be taken with regards to explosive, flammable dust, gas, vapour or substance. Combustible dust which could cause combustible dust explosion are also included under this clause. However, it was not explicitly stated in the clause that combustible dust is part of flammable dust. There is also no requirement for the occupier handling combustible dust to inform MOM or other agencies on the use of such material except for those flammable solids which are licensed under SCDF.

The Workplace Safety and Health Act (WSHA) covers duties of manufacturer and supplier of hazardous substances prescribed in the Fifth Schedule to provide information on the safe use of the hazardous substance. Additionally, the WSH (General Provisions) Regulations also require seller or agent of the seller of the hazardous substances to provide Safety Data Sheet that conforms to Singapore Standard SS 586 Part 3: Preparation of Safety Data Sheets (SDS), which conforms to the GHS. This is to ensure proper hazard communication to users of hazardous substances on the potential hazards and precautionary measures to take when handling and storing of these substances. As GHS classification does not include combustible dust hazard as one of the hazard classifications, chemicals which are toxic substances and pose combustible dust hazard, the label for the product will only cover the toxicity hazard but not combustible dust hazard. In addition, food products such as milk powder, plain flour are not deemed as hazardous substances, warning labels would not apply.

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
Customs	Regulation of Imports and Exports Act	Import	<p>All goods entering Singapore goes through Customs</p> <p>Regulations for registration, regulation and control of importation and exportation, etc.</p> <p>3.—(1) The Minister may make regulations for the registration, regulation and control of all or any class of goods imported into, exported from, transhipped in or in transit through Singapore. [6/2003 wef 01/04/2003]</p> <p>(2) Without prejudice to the generality of subsection (1), the Minister may make regulations —</p> <p>(a) for prohibiting, absolutely or conditionally, or for regulating, in all cases or in any specified case or class of cases and subject to such exceptions as may be made by the regulations, the import or export or the carriage coastwise or the shipment as ships'</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>stores or the transshipment or transit of all goods or of goods of any specified class or description;</p> <p>(b) for imposing on such importers, exporters, agents, forwarding agents, common carriers, consignors or consignees of goods or on owners, agents, masters or persons in charge of a conveyance as may be prescribed in the regulations, the duty to furnish —</p> <p style="padding-left: 40px;">(i) to the Director-General; or <i>[6/2003 wef 01/04/2003]</i></p> <p style="padding-left: 40px;">(ii) to the owner, agent, master or person in charge of a conveyance, or to a railway station-master or to such other person as may be prescribed, such particulars, information or documents relating to goods imported into, exported from, transhipped in or in transit through Singapore as may be prescribed;</p> <p>(c) for permitting the Director-General to authorise, in such manner as may be prescribed, the importation, exportation, transshipment or transit of goods in regard to which the required particulars, information or documents have been furnished; <i>[6/2003 wef 01/04/2003]</i></p> <p>(d) for prohibiting the importation, exportation, transshipment or transit of goods, or the delivery of goods or of documents relating to such goods, except in compliance with the regulations or with the approval of the Director-General; <i>[6/2003 wef 01/04/2003]</i></p> <p>(da) for prohibiting the exportation of all goods or goods of any specified class or description except in compliance with such conditions as may be prescribed for the</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>purpose of complying with any preferential tariff arrangement or agreement between Singapore and a country or territory outside Singapore, including any condition that the goods exported are to be from a prescribed source or that the manufacture of such goods is to be carried out or procured by any person registered under regulations made under this Act;</p> <p style="text-align: right;"><i>[28/2003 wef 01/01/2004]</i></p> <p>(e) for requiring the owner or agent of any conveyance to furnish particulars of coal, oil or other fuel or stores placed on board that conveyance in Singapore;</p> <p>(f) for determining the form and manner in which the required particulars, information and documents shall be furnished;</p> <p>(g) for prescribing the time within which the required particulars, information and documents shall be furnished;</p> <p>(h) for requiring the master of any vessel to attend at an examination station or the office of the Port Master, and to furnish such particulars, information and documents, as may be prescribed;</p> <p style="text-align: right;"><i>[6/2003 wef 01/04/2003]</i></p> <p>(i) for prohibiting the issue of a port clearance to the master of any vessel pending compliance with any provision of the regulations;</p> <p>(j) for the registration of all or such class of goods, as may be prescribed, imported into, exported from, transhipped in or in transit through Singapore;</p> <p>(k) for the registration of importers, exporters, common carriers of goods or any person making a declaration under this Act or any regulations made thereunder;</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p style="text-align: right;"><i>[Act 3 of 2014 wef 01/04/2014]</i></p> <p>(l) for the issue of certificates of entitlement to permits for the export or import of such classes of goods, as are prescribed, to successful applicants who submitted bids for the certificates;</p> <p>(m) for requiring fees and deposits to be paid for the submission of applications for the issue of certificates of entitlement under any regulations made under paragraph (l), and providing for the forfeiture of deposits for non-compliance with any of the conditions governing the submission of such applications;</p> <p>(n) for prescribing the levy, or the method or manner for determining the amount of the levy, payable for the import or export of different classes of goods or for a certificate of entitlement issued under any regulations made under paragraph (l) and for prescribing the manner or method in which such levy shall be paid;</p> <p>(na) for requiring security to be provided to secure compliance with this Act, any regulations made thereunder or any condition imposed under this Act or such regulations, and to make provision for the form, manner, amount, period and forfeiture of such security;</p> <p style="text-align: right;"><i>[28/2003 wef 01/01/2004]</i></p> <p>(o) for prescribing the fees and charges, or the method or manner for determining the amount of the fees or charges, payable by virtue of any regulations made under this section, and for prescribing the manner or method in which such fees or charges shall be paid;</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(p) for prescribing the fees to be charged for services and facilities provided by the Director-General; <i>[28/2003 wef 01/01/2004]</i> <i>[6/2003 wef 01/04/2003]</i></p> <p>(pa) for the bringing of appeals to the Minister in respect of any matter referred to in this Act or any regulations made thereunder, and the procedure for such appeals; <i>[28/2003 wef 01/01/2004]</i></p> <p>(q) for prescribing anything which is required to be prescribed under this Act or which is necessary or expedient to be prescribed for carrying out or giving effect to the provisions of this Act. <i>[6/2003 wef 01/04/2003]</i></p>
Customs	Regulation of Imports and Exports Regulations	Import	<p>Import permit/licence from respective agencies required in order to allow goods to enter Singapore</p> <p>Permit for import, export or transhipment</p> <p>3.—(1) Subject to paragraphs (2), (2A), (3) and (4) and regulation 5A, no goods shall be —</p> <p>(a) imported into Singapore;</p> <p>(b) exported out of Singapore; or</p> <p>(c) transhipped in Singapore,</p> <p>except in accordance with a permit granted by the Director-General under this Part. <i>[S 370/2013 wef 01/07/2013]</i> <i>[S 645/2017 wef 08/11/2017]</i></p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(2) The requirement in paragraph (1) for a permit to import, export or tranship any goods shall not apply if such goods are not controlled imports, controlled exports or controlled transhipments and are —</p> <ul style="list-style-type: none"> (a) personal or household effects, other than motor vehicles, which — <ul style="list-style-type: none"> (i) accompany passengers, crew or employees of transport undertakings by land, sea or air; (ii) are not being transported for sale but are intended for the personal or household use of such passengers, crew or employees of transport undertakings; and (iii) in the case of such household effects, are being transported for the purpose of a transfer of residence of the owner to Singapore or to a place outside Singapore; (b) being imported, exported or transhipped by parcel post; (c) diplomatic correspondence; (d) being imported, exported or transhipped by — <ul style="list-style-type: none"> (i) the joint defence force, including the Singapore Armed Forces, the Singapore Police Force and the Singapore Civil Defence Force, including personal and household effects of its officers but excluding civilian motor vehicles; or

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(ii) the Ministry of Foreign Affairs, including personal and household effects of its officers but excluding motor vehicles;</p> <p>(e) used motor vehicles covered by Carnet de Passage which are endorsed by the Automobile Association of Singapore;</p> <p>(f) trade samples, specimens for analysis or test, and gifts, the total value of which does not exceed \$400;</p> <p>(g) commercial, shipping or airline documents, press photographs or negatives, news write-ups, news clippings, news films or news transcription tapes;</p> <p>(h) human corpses, human remains, human bones or cremated ashes; or <i>[S 370/2013 wef 01/07/2013]</i></p> <p>(i) human transplant materials. <i>[S 370/2013 wef 01/07/2013]</i></p> <p>(2A) The requirement in paragraph (1) for a permit to import any goods shall not apply if such goods —</p> <p>(a) are not controlled imports;</p> <p>(b) have a total value which does not exceed \$400; and</p> <p>(c) are being imported by air. <i>[S 370/2013 wef 01/07/2013]</i></p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(3) The requirement in paragraph (1) for a permit to export any goods shall not apply if such goods —</p> <ul style="list-style-type: none"> (a) are not controlled exports; (b) have a total value which does not exceed \$1,000; and [S 370/2013 wef 01/07/2013] (c) are being exported by air. [S 370/2013 wef 01/07/2013] <p>(4) The requirement in paragraph (1) for a permit to tranship any goods shall not apply to goods —</p> <ul style="list-style-type: none"> (a) which are not controlled transshipments; and (b) which — <ul style="list-style-type: none"> (i) are not transhipped from one free trade zone to another; or (ii) are carried by air to and from Singapore during transhipment, and have a total value which does not exceed \$1,000.
Customs	Regulation of Imports and Exports Regulations	Import	<p>Application for import certificate</p> <p>28.—(1) An application for the issue of an import certificate under this regulation shall be —</p> <ul style="list-style-type: none"> (a) made by an importer of goods, whether he is the end-user or not; (b) made in such manner as the Director-General may determine;

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(c) made in triplicate in such form as the Director-General may determine with particulars of —</p> <ul style="list-style-type: none"> (i) the quantity, value and a complete description of the goods to be imported; (ii) the name and address of the end-user of the goods; and (iii) such undertaking or other information as the Director-General may require; and <p>(d) accompanied by —</p> <ul style="list-style-type: none"> (i) a declaration by the foreign exporter that the goods are subject to the export control of the exporting country; and (ii) such information or document as the Director-General may require. <p>(2) An import certificate issued by the Director-General under this regulation shall be in duplicate and shall be valid for the period specified in the certificate and shall be subject to such conditions as the Director-General may impose.</p> <p>(3) The Director-General may at any time vary or add to the conditions imposed under paragraph (2).</p> <p>(4) The validity of an import certificate may, on the application of the importer concerned before the expiry of the certificate, be extended for such period of time as the Director-General thinks fit.</p> <p style="text-align: right;"><i>[S 170/2003 wef 01/04/2003]</i></p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(5) Any person who breaches an undertaking given under paragraph (1)(c)(iii) or a condition imposed by this regulation shall be guilty of an offence.</p>
<p>SCDF</p>	<p>Fire Safety Act</p>	<p>Import, distribution (transport)</p>	<p>Import, transport licence for petroleum and flammable materials under the Act</p> <p>Import of petroleum and flammable materials</p> <p>35A.—(1) No person shall import any class of petroleum or any flammable material if —</p> <p>(a) the regulations require the person importing such petroleum or flammable material to hold a licence from the Commissioner to import such petroleum or flammable material; and</p> <p>(b) the person does not hold such a valid licence.</p> <p>(2) No person shall import any class of petroleum or any flammable material unless the importation —</p> <p>(a) is effected in accordance with the provisions of his licence and with every condition specified therein; and</p> <p>(b) is in such quantities and in such manner and in accordance with requirements prescribed in relation to such petroleum or flammable material.</p> <p style="text-align: right;"><i>[Act 14 of 2013 wef 01/09/2013]</i> <i>[7/2004 wef 16/02/2005]</i></p> <p>Transport of petroleum and flammable materials</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>35B.—(1) No person shall transport any class of petroleum or any flammable material (other than as a driver of a road vehicle) if —</p> <ul style="list-style-type: none"> (a) the regulations require the person transporting such petroleum or flammable material to hold a licence from the Commissioner to transport such petroleum or flammable material; and (b) the person does not hold such a valid licence. <p>(2) No person shall transport any class of petroleum or any flammable material (other than as a driver of a road vehicle) unless the transportation —</p> <ul style="list-style-type: none"> (a) is in accordance with the provisions of his licence and with every condition specified therein; and (b) is in such quantities and in such manner and in accordance with requirements prescribed in relation to such petroleum or flammable material. <p style="text-align: right;"><i>[Act 14 of 2013 wef 01/09/2013]</i></p> <p>(3) No person shall drive any vehicle transporting any class of petroleum or any flammable material by road if —</p> <ul style="list-style-type: none"> (a) the regulations require the vehicle to be licensed to transport such petroleum or flammable material and the vehicle is not licensed by the Commissioner to carry such petroleum or flammable material; and (b) the regulations require the person to hold a permit from the Commissioner to drive a vehicle carrying such petroleum or flammable material and the person does not hold such a valid permit.

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(4) No person shall drive any vehicle transporting any class of petroleum or any flammable material by road unless he does so in such manner and in accordance with requirements prescribed in relation to such petroleum or flammable material, and in accordance with the provisions of his permit and every condition specified therein.</p> <p style="text-align: right;"><i>[Act 14 of 2013 wef 01/09/2013]</i></p> <p>(5) Nothing in this section shall apply to petroleum or any flammable material in the fuel tank of a vehicle which is used or intended to be used as fuel for that vehicle.</p> <p>(6) Every permit issued by the Commissioner before the date of commencement of section 16 of the Fire Safety (Amendment) Act 2004 authorising any person to drive any vehicle transporting any class of petroleum or any flammable material by road shall be deemed to have been issued under subsection (3)(b).</p> <p style="text-align: right;"><i>[7/2004 wef 16/02/2005]</i></p>
SCDF	Fire Safety Act	Storage, Use	<p>Storage of petroleum and flammable materials</p> <p>35. No person shall store or keep, or cause to be stored or kept, any class of petroleum or any flammable material except —</p> <p style="padding-left: 40px;">(a) in or on licensed premises;</p> <p style="text-align: right;"><i>[Act 14 of 2013 wef 01/09/2013]</i></p> <p style="padding-left: 40px;">(b) in such quantities and in such manner and in accordance with requirements prescribed in relation to such petroleum or flammable material; and</p> <p style="text-align: right;"><i>[Act 14 of 2013 wef 01/09/2013]</i></p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(c) under the authority of and in accordance with the provisions of a storage licence from the Commissioner and every condition specified therein.</p> <p style="text-align: right;"><i>[Act 14 of 2013 wef 01/09/2013]</i> <i>[7/2004 wef 16/02/2005]</i></p> <p>Pipelines for petroleum and flammable materials</p> <p>36A. No pipeline owner shall convey, or allow the conveyance of, any class of petroleum or any flammable material through any section of a relevant pipeline in relation to which he is the pipeline owner except under the authority of and in accordance with the provisions of a pipeline licence from the Commissioner and every condition specified therein.</p>
SCDF	Fire Safety (Petroleum and Flammable Materials) Regulations	Distribution (Transport)	<p>Application for licence to transport petroleum or flammable materials</p> <p>5.—(1) An application for a licence to transport any petroleum or flammable material or both in a vehicle shall be made by the person intending to transport the petroleum or flammable material or both.</p> <p>(2) A separate application for a licence to transport any petroleum or flammable material or both shall be made in respect of each particular vehicle in which the petroleum or flammable material or both are to be transported; and each such application shall also be regarded as an application for a licence for that vehicle to transport the petroleum or flammable material or both.</p> <p>(3) Subject to paragraphs (4) and (5), every application for a licence to transport any petroleum or flammable material or both in a vehicle shall be accompanied by the following documents:</p> <p>(a) a test certificate on the roadworthiness of the vehicle issued by the Land Transport Authority of Singapore under section 90 of the Road Traffic Act (Cap. 276);</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(b) a copy of the Transport Emergency Response Plan for that vehicle;</p> <p>(c) a certificate of inspection of that vehicle from an approved inspector;</p> <p>(d) a list of drivers to be employed by the applicant to transport petroleum or flammable materials in that vehicle;</p> <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p> <p>(e) if required by the Commissioner, a quantitative risk assessment or any other risk analysis report on the transport of the petroleum or flammable materials in the vehicle from any person who in the view of the Commissioner is qualified to give such report; and</p> <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p> <p>(f) such other documents or particulars as the Commissioner may require in any particular case.</p> <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p> <p>(4) Where the application is for a licence to transport any petroleum or flammable material or both in bulk, the application shall be accompanied by the following additional documents:</p> <p>(a) the manufacturer's specifications and design plans of the tank to be used in the transport;</p> <p>(b) a hydrostatic test report or any equivalent test report, certified in accordance with an accepted code of practice by a professional engineer in the mechanical engineering discipline or by such other person acceptable to the Commissioner;</p> <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(ba) a radiographic test report or any equivalent test report of the tank, certified in accordance with an accepted code of practice by a professional engineer in the mechanical engineering discipline or by any other person acceptable to the Commissioner; and</p> <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p> <p>(c) a copy of the plan of the vehicle showing the following particulars:</p> <ul style="list-style-type: none"> (i) the location of the vehicle engine, fuel tank, exhaust system and pipe, batteries and pump or compressor (if any) and where any of these components are encased, the type of material used to encase them, and the type of material that is used to construct the rear portion of the driver's cab facing the tank; (ii) the water capacity of the vehicle's tank; (iii) the location and nature of all openings, fittings, gauges, emergency shut-off valves, excess flow valves, or any other safety valves or devices and their means of closure and capacities, where applicable; and (iv) the location, size and type of all fire extinguishers provided in the vehicle. <p>(5) Where the application is for a licence to transport petroleum or flammable materials in package, the application shall be accompanied by the following additional documents:</p> <ul style="list-style-type: none"> (a) a letter from the applicant certifying that —

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(i) he has checked the vehicle which is to be used to transport the petroleum or flammable material; and</p> <p>(ii) he is satisfied that the condition of the vehicle is in compliance with the Act and these Regulations; and</p> <p>(b) a letter of authorisation from the supplier of the petroleum to be transported, if the applicant is not a supplier.</p> <p>(6) Where the applicant for a licence to transport any petroleum or flammable material or both in any vehicle is not the owner of the vehicle, the application shall also be accompanied by the consent in writing of the owner of the vehicle or of the legal personal representative, if the owner is deceased.</p> <p>(7) Paragraph (4)(b) shall not apply to an application for the renewal of a licence to transport any petroleum or flammable material or both in a vehicle if, within the 5 years prior to that application, the applicant has complied with that provision on at least one occasion either when making an application for the licence or an application for the renewal of the licence.</p> <p style="text-align: right;"><i>[S 546/2013 wef 01/09/2013]</i></p> <p>(8) Paragraph (4)(ba) shall not apply to an application for the renewal of a licence to transport any petroleum or flammable material or both in a vehicle if, within the 10 years prior to that application, the applicant has complied with that provision on at least one occasion either when making an application for the licence or an application for the renewal of the licence.</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
SCDF	Fire Safety (Petroleum and Flammable Materials) Regulations	Import	<p>Import of petroleum or flammable materials in excess of Second Schedule quantity requires licence</p> <p>15. The import of any class of petroleum or any flammable material in excess of the respective quantities specified in the Second Schedule shall require a licence to import.</p>
SCDF	Fire Safety (Petroleum and Flammable Materials) Regulations	Storage	<p>Application for licence to store or keep petroleum or flammable materials</p> <p>4.—(1) An application for a licence to store or keep any petroleum or flammable material or both at any premises shall be made by the person intending to store or keep the petroleum or flammable material or both.</p> <p>(2) A separate application for a licence to store or keep any petroleum or flammable material or both shall be made in respect of each particular premises at which the petroleum or flammable material or both are to be stored or kept; and each such application shall also be regarded as an application for a licence for those premises to store or keep that petroleum or flammable material or both.</p> <p>Application for pipeline licence</p> <p>4A.—(1) An application for a pipeline licence to convey any class of petroleum or flammable material through any section of a relevant pipeline shall be made by the pipeline owner of that section of the relevant pipeline.</p>
SCDF	Fire Safety Act	Use, Storage (Building Work approval)	<p>Prohibition of fire safety works without approval of plans</p> <p>24.—(1) A person must not carry out, or permit or authorise the carrying out of, any fire safety works —</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(a) before the Commissioner has approved all the plans of the fire safety works under section 23; or</p> <p>(b) otherwise than in accordance with the plans approved under section 23.</p> <p style="text-align: right;"><i>[Act 22 of 2019 wef 14/09/2020]</i></p>
SCDF	Fire Safety (Building and Pipeline Fire Safety) Regulations	Use, Storage (Building Work approval)	<p>Application for approval of plans of fire safety works</p> <p>3. For the purposes of section 23(1) of the Act, an application for the approval of plans of any fire safety works shall be in such form as the Commissioner may provide and shall be accompanied by the prescribed fees and by the following documents:</p> <p>(a) the following plans of fire safety works:</p> <ul style="list-style-type: none"> (i) building plans (where the fire safety works relate to any building) or relevant pipeline plans (where the fire safety works relate to any relevant pipeline); <p style="text-align: right;"><i>[S 545/2013 wef 01/09/2013]</i></p> <ul style="list-style-type: none"> (ii) air-conditioning and mechanical ventilation plans; and (iii) fire protection plans; <p>(b) a notification signed by the applicant of the appointment of —</p> <ul style="list-style-type: none"> (i) the qualified person who prepared the plans of fire safety works; and (ii) where the plans of fire safety works contain any alternative solution, the fire safety engineer who prepared or supervised the preparation of the plans,

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p style="text-align: right;"><i>[S 545/2013 wef 01/09/2013]</i></p> <p>and a confirmation of such appointment signed by the qualified person and, where applicable, the fire safety engineer;</p> <p>(c) the applicable declaration form set out on the website at https://www.scdf.gov.sg; <i>[S 769/2020 wef 14/09/2020]</i></p> <p>(d) where the plans of fire safety works contain any alternative solution, the additional following documents:</p> <ul style="list-style-type: none"> (i) a fire safety engineering design brief; (ii) a fire safety engineering report, including detailed specifications and drawings of the final design of fire safety works; (iii) an operations and maintenance manual for the building or relevant pipeline, as the case may be, to which the fire safety works relate; <i>[S 545/2013 wef 01/09/2013]</i> (iv) a notification signed by the applicant of the appointment of a peer reviewer and a confirmation of such appointment signed by the peer reviewer; and (v) a peer reviewer's report as to whether the alternative solution satisfies the fire performance requirements in the Fire Code; <i>[S 545/2013 wef 01/09/2013]</i> <i>[S 769/2020 wef 14/09/2020]</i>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(e) where the plans of fire safety works involve the use of any building materials or equipment not specified in the Fire Code — a description of the nature and type of all the building materials or equipment to be used in the fire safety works; <i>[S 769/2020 wef 14/09/2020]</i></p> <p>(f) other documentary evidence in support of any documents in paragraphs (a) to (e), and such other documents as the Commissioner may require to decide the application.</p>
SFA	Sale of Food Act	Import, Distribution	<p>(Requires labelling based on food safety/quality considerations)</p> <p>Offences concerning labelling</p> <p>16.—(1) A person must not sell any food that is packaged or labelled in a manner that does not comply with all applicable requirements of this Act relating to identification and labelling of that food.</p>
SFA	Food Regulations	Import, Distribution	<p>General requirements for labelling</p> <p>5.—(1) No person shall import, advertise, manufacture, sell, consign or deliver any prepacked food if the package of prepacked food does not bear a label containing all the particulars required by these Regulations.</p> <p>(2) Every package of prepacked food shall, unless otherwise provided in these Regulations, bear a label, marked on or securely attached in a prominent and conspicuous position to the package, containing such particulars, statements, information and words in English as are required by the Act and these Regulations.</p> <p>(3) The particulars, statements, information and words referred to in paragraph (2) shall appear conspicuously and in a prominent position on the label and shall be clearly legible.</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(4) The particulars referred to in paragraph (3) shall include —</p> <p>(a) the common name, or a description (in the case where a suitable common name is not available) sufficient to indicate the true nature of the food;</p> <p>(b) the appropriate designation of each ingredient in the case of food consisting of two or more ingredients and unless the quantity or proportion of each ingredient is specified, the ingredients shall be specified in descending order of the proportions by weight in which they are present.</p> <p>For the purpose of this sub-paragraph —</p> <p>(i) “appropriate designation” means a name or description, being a specific and not a generic name or description, which shall indicate to a prospective purchaser the true nature of the ingredient, constituent or product to which it is applied except as provided in the First Schedule;</p> <p>(ii) it shall not be necessary to state that the food contains water; and</p> <p>(iii) where a food contains an ingredient which is made from two or more constituents, the appropriate designations of those constituents shall be so specified and it shall not be necessary to specify the appropriate designation of that ingredient;</p> <p>(c) either one of the following statements in specification of ingredients in the case of a food which contains the synthetic colouring, tartrazine:</p> <p>(i) tartrazine;</p> <p>(ii) colour (102);</p> <p>(iii) colour (FD&C Yellow #5) or other equivalent terms;</p> <p>(d) the net quantity of the food in the wrapper or container expressed in the following manner:</p> <p>(i) for liquid foods, by volume;</p> <p>(ii) for solid foods, by weight;</p> <p>(iii) for semi-solid or viscous foods, either by weight or volume; and</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			(iv) for a food packed in a liquid medium, by net weight of the food together with the liquid medium, and by drained weight of the food.
SFA	Feeding Stuffs Act	Use, Storage	<p>Licence to import, manufacture, etc., animal feeds</p> <p>4.—(1) The Director-General may issue a licence to any person to import, manufacture, process for sale or sell simple feeds, feed concentrates or compound feeds upon an application made in the prescribed form and the payment of such fees as may be prescribed.</p> <p>(2) A licence shall be subject to such conditions as may be prescribed and such other conditions as the Director-General may, in his discretion, impose.</p> <p>(3) The Director-General may, in his discretion, at any time, revoke or suspend a licence.</p> <p>(4) No person shall import, manufacture, process for sale or sell simple feeds, feed concentrates or compound feeds without a licence issued by the Director-General.</p>
MOM	Workplace Safety and Health (Major Hazard Installations) Regulations	Use, Storage	<p>Implementation of safety case</p> <p>6. Subject to regulation 11(4), the occupier of a major hazard installation or deemed major hazard installation must implement the safety case for the major hazard installation or deemed major hazard installation by doing all of the following:</p> <ul style="list-style-type: none"> (a) implement the major accident prevention policy for the major hazard installation or deemed major hazard installation; (b) ensure that the person mentioned in paragraph 1(b) of Part 2 of the Third Schedule carries out the roles and responsibilities specified in that paragraph; (c) implement the plan mentioned in paragraph 1(d) of Part 2 of the Third Schedule; (d) implement the safety and health management system in accordance with the Workplace Safety and Health (Safety and Health Management System and Auditing) Regulations 2009 (G.N. No. S 607/2009); (e) ensure that the necessary resources, mentioned in paragraph 3 of Part 2 of the Third Schedule, are available for implementing the major accident prevention policy;

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(f) implement the preventive measures mentioned in paragraph 5(a) of Part 2 of the Third Schedule;</p> <p>(g) ensure that the processes carried out in the major hazard installation or deemed major hazard installation are carried out in accordance with the description in paragraph 5(b) of Part 2 of the Third Schedule;</p> <p>(h) operate the major hazard installation or deemed major hazard installation in accordance with the description mentioned in paragraph 6(f) of Part 2 of the Third Schedule;</p> <p>(i) implement the measures mentioned in paragraph 7 of Part 2 of the Third Schedule.</p>
NEA	Environmental Protection and Management Act	Use, Storage (Development control)	<p>Written permission for use of scheduled premises</p> <p>6.—(1) No person shall occupy or use any scheduled premises specified in the First Schedule without a written permission granted by the Director-General.</p> <p>(2) Any person who contravenes subsection (1) shall be guilty of an offence.</p> <p>(3) Any application for a written permission under this section shall be made to the Director-General giving details of —</p> <p>(a) the trade, industry or process proposed to be carried in or on the premises;</p> <p>(b) the measures the applicant undertakes to adopt to control air, water and noise pollution from the premises; and</p> <p>(c) the measures the applicant undertakes to adopt to manage hazardous substances and to treat and dispose of toxic substances originating from or stored within the premises.</p> <p>Permit for certain works on scheduled premises</p> <p>8.—(1) The owner or occupier of any scheduled premises shall not without a permit granted by the Director-General —</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(a) alter the method of operation of any trade or industrial process, fuel burning equipment, control equipment, treatment plant or industrial plant in or on the scheduled premises;</p> <p>(b) install, alter or replace any fuel burning equipment, control equipment, treatment plant or industrial plant in or on the scheduled premises;</p> <p>(c) erect or alter the height or dimension of any chimney through which air impurities may be emitted from the scheduled premises; or</p> <p>(d) use any fuel other than the type of fuel specified in writing by the Director-General.</p> <p>First Schedule</p> <p>Scheduled Premises</p> <p>Scheduled premises are any premises —</p> <p>(a) being used for —</p> <p>(i) cement works, being works for the manufacture or packing of portland cement, similar cement or pozzolanic materials;</p> <p>(ii) concrete works, being works for the manufacture of concrete and of each batch capacity greater than 0.5 cubic metre;</p> <p>(iii) asphalt works, being works for the manufacture of asphalt or tarmacadam;</p> <p>(iv) ceramic works, being works in which any products such as bricks, tiles, pipes, pottery goods, refractories or glass are manufactured in furnaces or kilns fired by any fuel;</p> <p>(v) chemical works, being works in which acids, alkali, chemical fertilizer, soap, detergent, sodium silicates, lime or other calcium compounds, chlorine, chemicals or chemical products are manufactured;</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(vi) coke or charcoal works, being works in which coke or charcoal is produced and quenched, cut, crushed or graded;</p> <p>(vii) ferrous and non-ferrous metal works, being works in which metal melting processes for casting and/or metal coating are carried out;</p> <p>(viii) gas works, being works in which coal, coke, oil or other mixtures or derivatives are handled or prepared for carbonisation or gasification and in which such materials are subsequently carbonised or gasified;</p> <p>(ix) crushing, grinding and milling works, being works in which rock, ores, minerals, chemicals or natural grain products are processed by crushing, grinding, milling or separating into different sizes by sieving, air elutriation or in any other manner;</p> <p>(x) petroleum works, being works in which crude or shale oil or crude petroleum or other mineral oil is refined or reconditioned;</p> <p>(xi) scrap metal recovery works, being works in which scrap metals are treated in any type of furnace for recovery of metal irrespective of whether this is the primary object of any specific premises or not;</p> <p>(xii) primary metallurgical works, being works in which ores are smelted or converted to metal of any kind;</p> <p>(xiii) pulping works, being works in which wood or cellulose material is made into pulp;</p> <p>(xiv) abrasive blasting works, being works in which equipment or structures are cleaned by abrasive blasting;</p> <p>(b) on which there is erected any boiler of steam generating capacity of 2,300 kilogrammes or more per hour, incinerator or furnace burning 500 kilogrammes or more of solid combustible material per hour or 220 kilogrammes or more of liquid material per hour; or</p> <p>(c) being used or intended to be used for storing —</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(i) more than 100 tonnes of one or more of the following substances: chemicals, chemical products, hydrocarbons or hydrocarbon products which are toxic or which produce toxic gases on burning or on contact with water or air; or</p> <p>(ii) more than 1,000 tonnes of one or more of the following substances: chemicals, chemical products, hydrocarbons or hydrocarbon products with a flash point lower than 55°C.</p>
NEA	Environmental Protection and Management (Air Impurities) Regulations	Use	<p>Standards of concentration of air impurities</p> <p>4.—(1) For the purposes of section 12 of the Act, the standards of concentration of air impurities that must be complied with in the conduct of any trade, industry or process or the operation of any fuel burning equipment or industrial plant shall be those specified in the Schedule.</p> <p>(2) The concentration of any substance specified in the first column of the Schedule shall be determined in accordance with such method as may be specified by or is acceptable to the Director-General.</p> <p>The Schedule</p> <p style="text-align: center;">STANDARDS OF CONCENTRATION OF AIR IMPURITIES</p> <p>1. The concentration of any substance specified in the first column emitted from any operation in any trade, industry, process, fuel burning equipment or industrial plant specified in the second column shall not at any point before admixture with air, smoke or other gases, exceed the limits specified in the third column.</p>

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations		
			<i>Substance</i>	<i>Trade, industry, process, fuel burning equipment or industrial plant</i>	<i>Emission limits</i>
			(a) Ammonia and ammonium compounds	Any trade, industry or process	30 mg/Nm ³ expressed as ammonia
			(b) Antimony and its compounds	Any trade, industry or process	5 mg/Nm ³ expressed as antimony
			(c) Arsenic and its compounds	Any trade, industry or process	1 mg/Nm ³ expressed as arsenic
			(d) Benzene	Any trade, industry or process	5 mg/Nm ³
			(e) Cadmium and its compounds	Any trade, industry or process	0.05 mg/Nm ³ expressed as cadmium
			(f) Carbon monoxide	Any trade, industry, process or fuel burning equipment	250 mg/Nm ³
			(g) Chlorine	Any trade, industry or process	32 mg/Nm ³
			(h) Copper and its compounds	Any trade, industry or process	5 mg/Nm ³ expressed as copper

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations	
			(i) Dioxins and furans	Any waste incinerator (i) 1.0 ng TEQ/Nm ³ for waste incinerators commissioned before 1st January 2001 (ii) 0.1 ng TEQ/Nm ³ for waste incinerators commissioned on or after 1st January 2001
			(j) Ethylene oxide	Any trade, industry or process 5 mg/Nm ³
			(k) Fluorine, hydrofluoric acid or inorganic fluorine compounds	Any trade, industry or process 10 mg/Nm ³ expressed as hydrofluoric acid
			(l) Formaldehyde	Any trade, industry or process 20 mg/Nm ³
			(m) Hydrogen chloride	Any trade, industry or process 200 mg/Nm ³
			(n) Hydrogen sulphide	Any trade, industry or process 7.6 mg/Nm ³
			(o) Lead and its compounds	Any trade, industry or process 0.5 mg/Nm ³ expressed as lead
			(p) Mercury and its compounds	Any trade, industry or process 0.05 mg/Nm ³ expressed as mercury

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations	
			(q) Oxides of nitrogen	Any trade, industry, process or fuel burning equipment 400 mg/Nm ³ expressed as nitrogen dioxide
			(r) Particulate substances including smoke, soot, dust, ash, fly-ash, cinders, cement, lime, alumina, grit and other solid particles of any kind	(i) 50 mg/Nm ³ ; or (ii) where there is more than one flue, duct or chimney in any scheduled premises, the total mass of the particulate emissions from all of such flue, duct or chimney divided by the total volume of such emissions shall not exceed 50 mg/Nm ³ and the particulate emissions from each of such flue, duct or chimney shall not exceed 100 mg/Nm ³ at any point in time.
			(s) Styrene monomer	Any trade, industry or process 100 mg/Nm ³

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations	
			(t) Sulphur dioxide (non-combustion sources)	Any trade, industry or process 500 mg/Nm ³
			(ta) Sulphur dioxide (combustion sources)	Any trade, industry or process (i) 1,700 mg/Nm ³ (ii) where there is more than one flue, duct or chimney in any scheduled premises, the total mass of the sulphur dioxide emissions from all of such flue, duct or chimney divided by the total volume of such emissions must not exceed 1,700 mg/Nm ³ on a daily basis.
			(u) Sulphur trioxide and other acid gases	The manufacture of sulphuric acid 500 mg/Nm ³ expressed as sulphur trioxide. Effluent gases shall be free from persistent mist.

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations						
			<table border="1"> <tr> <td>(v) Sulphur trioxide or sulphuric acid mist</td> <td>Any trade, industry or process, other than any combustion process and any plant involving the manufacture of sulphuric acid</td> <td>100 mg/Nm³ expressed as sulphur trioxide</td> </tr> <tr> <td>(w) Vinyl chloride monomer</td> <td>Any trade, industry or process</td> <td>20 mg/Nm³</td> </tr> </table> <p style="text-align: right;"><i>[S 369/2015 wef 01/07/2015]</i></p>	(v) Sulphur trioxide or sulphuric acid mist	Any trade, industry or process, other than any combustion process and any plant involving the manufacture of sulphuric acid	100 mg/Nm ³ expressed as sulphur trioxide	(w) Vinyl chloride monomer	Any trade, industry or process	20 mg/Nm ³
(v) Sulphur trioxide or sulphuric acid mist	Any trade, industry or process, other than any combustion process and any plant involving the manufacture of sulphuric acid	100 mg/Nm ³ expressed as sulphur trioxide							
(w) Vinyl chloride monomer	Any trade, industry or process	20 mg/Nm ³							
NEA	Environmental Public Health Act	Disposal	<p>Dangerous substance or toxic industrial waste not to be brought to disposal facility without permission</p> <p>29.—(1) No person who owns or is in possession of any dangerous substance or toxic industrial waste or the residue from the treatment thereof shall bring or cause to be brought such substance or waste to any disposal facility for disposal without the written permission of the Director-General.</p> <p style="text-align: right;"><i>[2/96; 4/2002]</i></p> <p>Licensing of persons carrying on business of collecting, removing, etc., of refuse or waste</p> <p>31.—(1) No person shall carry on the business of collecting, removing, transporting, storing or importing refuse or waste of any description without a waste collector licence granted by the Director-General under this section.</p> <p style="text-align: right;"><i>[2/96; 4/2002]</i></p>						

Agency	Regulations	Stage of supply chain	Extract of Relevant Singapore's Act/Regulations
			<p>(2) The Director-General may grant a licence authorising any person to carry on the business of collecting, removing, transporting, storing or importing refuse or waste of any description.</p> <p style="text-align: right;"><i>[2/96; 4/2002]</i></p>
NEA	Environmental Public Health (Toxic Industrial Waste) Regulations	Disposal	<p>No person to act as toxic industrial waste collector without licence</p> <p>9. No person shall —</p> <ul style="list-style-type: none"> (a) carry on or advertise, notify or state that he carries on or is willing to carry on the business of a toxic industrial waste collector; (b) act as a toxic industrial waste collector; or (c) in any way hold himself out as ready to undertake for payment or other remuneration (whether monetary or otherwise) any of the functions of a toxic industrial waste collector, <p>unless he is the holder of a toxic industrial waste collector's licence.</p>