

ALARP Demonstration Guidelines: Single Scenario Risk Tolerability Target and Adequacy of Barriers

Revision 1

Oct 2020

About this set of Guidelines:

Under the Workplace Safety and Health (Major Hazard Installations) Regulations 2017, Major Hazard Installations (MHIs) are required to demonstrate that their risks are identified and managed to as low as reasonably practicable (“ALARP”).

This document, “ALARP Demonstration Guidelines: Single Scenario Risk Tolerability Target and Adequacy of Barriers”, is intended to provide guidance to MHIs on:

- Risk tolerability targets, so that residual risks of Safety Critical Events (SCEs) are within the ALARP region of the risk tolerability target, taking into consideration the available barriers.
- The methodology for MHIs to assess whether adequate barriers have been provided to manage the risk of the identified major accident scenarios to ALARP.
- A list of references to guide MHIs in assessing the adequacy and robustness of their barriers.
- An implementation roadmap, specifying the target dates for phased implementation of the risk tolerability target and adequacy of barriers assessment.

Revision Records:

Revision	Revision Date	Description
1	26 October 20	Updated Title of Figure 1 to remove “Proposed”

ALARP Demonstration Guidelines:

Single Scenario Risk Tolerability Target and Adequacy of Barriers

1. Objective

- 1.1 This document aims to provide guidance to MHIs, towards achieving sound ALARP demonstrations in their Safety Cases.
- 1.2 The guidelines herein focus on the adequacy of preventive and mitigation barriers, to demonstrate that the risks of the identified scenarios are reduced to ALARP. This is done through:
 - a) Establishing a single scenario risk target; and
 - b) Providing guidance and references to accepted practices for assessing risks arising from major hazards.
- 1.3 Although this guideline is developed for ALARP demonstration associated with Safety Critical Events (SCEs), MHIs are encouraged to use the risk target defined, where applicable, in this guideline to manage risks arising from major accident hazards.

2. Scope

- 2.1 This guide is to be read in conjunction with the requirements in the Safety Case Assessment Guide, which can be downloaded at: <https://mom.gov.sg/workplace-safety-and-health/major-hazard-installations/preparing-for-safety-case>.

3. Single Scenario Risk Target

- 3.1 In establishing these guidelines, various jurisdictions worldwide were reviewed to benchmark the risk target with typical industry risk tolerance target and practices.
- 3.2 Most jurisdictions around the world, including Singapore, adopt the individual risk and/or societal risk approach for land use planning purposes. These approaches typically require the conduct of a Quantitative Risk Assessment (QRA), which presents risks in a cumulative manner.
- 3.3 Under the Safety Case regime, MHIs are required to perform ALARP demonstration for SCEs. By establishing a single scenario risk target¹, MHIs will be able to evaluate the risk of each SCE and determine, through the implementation of adequate and robust barriers, whether the risk is reduced to ALARP.

¹ A single scenario starts with a single initiating event and ends with a final outcome or consequence. An example of such is a single cause – top event – consequence path in a bow-tie diagram.

3.4 In developing the single scenario risk target, due considerations were given to alleviate the potential challenges faced by existing facilities in meeting the risk target. The single scenario risk target is presented below:

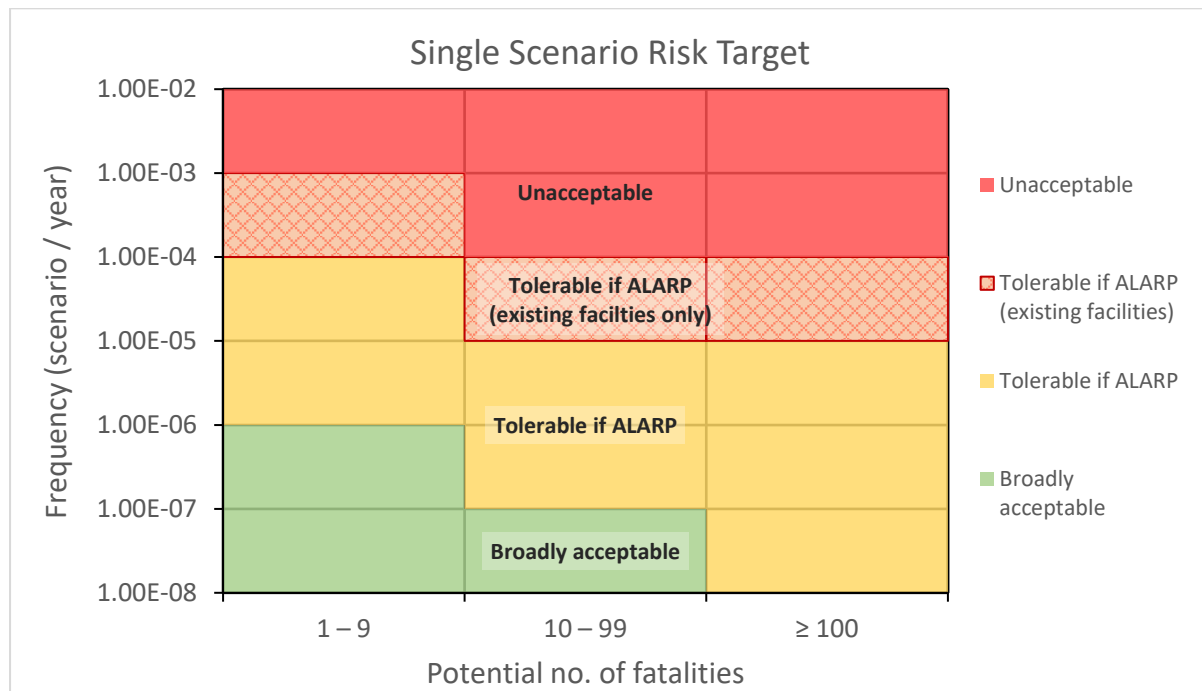


Figure 1. Single Scenario Risk Target

3.5 The threshold for risk deemed “Unacceptable” and “Tolerable² if ALARP” differs for new and existing facilities. The orange shaded region is deemed as “Unacceptable” for new facilities, and as “Tolerable if ALARP” for existing facilities. The target is also replicated in a tabular form below, for new and for existing facilities.

For **new** facilities:

Consequence (no. of fatalities ³)	Frequency range for each risk level (scenario / year)		
	Unacceptable	Tolerable if ALARP	Broadly Acceptable
1 – 9	> 1E-04	> 1E-06 – 1E-04	≤ 1E-06
10 – 99	> 1E-05	> 1E-07 – 1E-05	≤ 1E-07
≥ 100	> 1E-05	≤ 1E-05	-

² Tolerable – Level of risk deemed acceptable in order to achieve particular benefits, given that the risk is properly controlled.

³ Considers the potential number of fatalities within plant boundary and off-site

For **existing** facilities:

Consequence (no. of fatalities)	Frequency range for each risk level (scenario / year)		
	Unacceptable	Tolerable if ALARP	Broadly Acceptable
1 – 9	> 1E-03	> 1E-06 – 1E-03	≤ 1E-06
10 – 99	> 1E-04	> 1E-07 – 1E-04	≤ 1E-07
≥ 100	> 1E-04	≤ 1E-04	-

- 3.6 This calibrated approach was applied to differentiate between new and existing facilities, and account for potential limitations of existing facilities in meeting the target. The suitability of the risk target for both new and existing facilities will also be assessed and monitored on a regular basis, and may be adjusted as the Safety Case regime matures, or following technological advancements in process safety, etc.
- 3.7 MHIs with an existing single scenario risk target should review it against Figure 1. For existing risk targets that are comparable with Figure 1, no further revision may be required.
- 3.8 The risk target is intended for use by MHIs to evaluate the risk level of any single scenario. The rigour of ALARP demonstration is expected to be proportionate to the risk levels – the higher the risk, the greater the rigour of ALARP demonstration. For details on how to demonstrate ALARP, please refer to chapter 7 of the “Safety Case Technical Guide” and chapter 10 of the “Safety Case Assessment Guide”.
- 3.9 The description and requirements of the various risk levels are:

Risk Level	Description and requirements
Broadly Acceptable	Risk is perceived to be broadly acceptable if good practices and sound engineering principles relevant to these single scenarios have been followed, and if existing safeguards are effective and well managed.
Tolerable if ALARP	Risk is perceived to be tolerable if it is demonstrated in a structured and logical manner, based on sound engineering principles, that any incremental sacrifice to implement further risk reduction measures does not derive significant additional benefit. The evaluation should also consider whether a control measure can be implemented based on the current technological capabilities.

Risk Level	Description and requirements
Tolerable if ALARP, Existing Facilities Only	<p>a) For new facilities ⁴ , this is equivalent to the “Unacceptable” level as new facilities have greater opportunities to explore and implement risk reduction measures in the design phase.</p> <p>b) For existing facilities⁵, this is equivalent to the “Tolerable if ALARP” level. The rigour of ALARP demonstration is expected to be proportionate to the risk levels.</p> <p>c) To avoid having the need to manage 2 bands of risk levels for different equipment onsite, existing facilities are strongly encouraged to explore means and opportunities to meet with the new facilities’ risk target.</p>
Unacceptable	Risk is perceived to be unacceptable unless risk reduction measures are implemented to further reduce the risk level to ALARP. MHIs would need to develop action plans and implement risk reduction measures at the earliest opportunity. The action plans should include responsibilities, accountabilities and timescale for implementation.

Table 1: Description and requirements for the various risk levels

3.10 After alignment with this set of guidelines, should MHIs face difficulties in meeting the MHI’s own risk target, they can approach the Major Hazards Department (MHD) for discussion.

4. Guidance for Assessing Barrier Adequacy

For consistent application of the risk tolerability target, the following guiding principles apply:

- 4.1 MHIs are required to assess and demonstrate the residual risk for all SCEs, using their existing scenario risk target, or the risk target in Figure 1. The extent of demonstration is commensurate with the risk of the selected scenario, i.e. greater risks would require more rigour in ALARP demonstrations. MHI can refer to Chapter 7 of the Safety Case Technical Guide for the key concepts underpinning ALARP demonstration.
- 4.2 The demonstration should consider the initiating events of the SCEs as well as the existing safeguards in place to prevent the major accident scenario from being realised, or mitigate the consequence from the scenario. Layer of Protection Analysis (LOPA) or

⁴ New facilities - Greenfield facilities and expansions / modifications to brownfield facilities, where the first cycle Safety Case was submitted on and after 1 January 2022.

⁵ Existing facilities – Any facility where the first cycle Safety Case was submitted before 1 January 2022.

other sound engineering methods are recommended for MHIs to demonstrate the adequacy of existing barriers.

- 4.3 When assessing whether additional risk reduction measures are required, MHIs can use the 'tolerable if ALARP' region as the minimum risk target.
- 4.4 For additional guidance on the LOPA methodology, MHIs could refer to the list of references in section 5. The references provide guidance on determining the frequencies of initiating events and risk reduction factors of safeguards. Adherence to the guidance would assist MHIs in justifying the values employed in the LOPA methodology, so that Safety Cases clearly demonstrate the effectiveness, independence and auditability of each safeguard.

5. List of References

- 5.1 MHIs can refer to the following publications for guidance on assessing adequacy and robustness of safeguards:

Center for Chemical Process Safety, 2001. *Layer of Protection Analysis, Simplified Process Risk Assessment*

Center for Chemical Process Safety, 2009. *Guidelines for Developing Quantitative Safety Risk Criteria*

Center for Chemical Process Safety, 2014. *Guidelines for Enabling Conditions and Conditional Modifiers in Layer of Protection Analysis*

Center for Chemical Process Safety, 2015. *Guidelines for Initiating Events and Independent Protection Layers in Layer of Protection Analysis*

International Electrotechnical Commission (IEC), 2016. *Functional Safety - Safety Instrumented Systems for Process Industry Sector*. IEC 61511

6. Implementation Roadmap

- 6.1 To ease the challenges faced during implementation by MHIs, a roadmap depicting a phased implementation approach is provided:

No.	Description	Target Date
1	<p><u>Competency development in assessing adequacy of barriers</u> (section 5)</p> <p>MHIs to:</p> <ul style="list-style-type: none"> • Build competency; and • Develop or adopt appropriate guidelines for assessing adequacy and robustness of barriers. 	1 June 2021
2	<p><u>Establishment of single scenario risk target</u></p> <p>MHIs with an existing risk target to assess their single scenario risk target against this set of guidelines. For existing risk targets that are comparable with Figure 1, no further revision may be required.</p> <p>MHIs without an existing a single scenario risk target, to adopt Figure 1.</p>	All Safety Case submissions on and after 1 January 2022, for new and existing facilities.
3	<p><u>Conduct of risk assessment and ALARP demonstration</u></p> <p>MHIs to assess whether existing SCEs meet the risk target.</p> <p>Where the existing SCEs do not meet the risk target, MHIs are required to develop action plans to reduce risks towards ALARP. All ALARP demonstrations are to be included in Safety Cases.</p>	All Safety Case submissions on and after 1 January 2022, for new and existing facilities.
4	Implementation of any risk reduction measures	MHIs to discuss with MHD, on an individual MHI basis

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