

Second edition  
2022-12

---

---

## **Guidance on performing risk assessment in the design of onshore LNG installations including the ship/ shore interface**

*Recommandations sur l'évaluation des risques dans la conception  
d'installations terrestres pour le GNL en incluant l'interface terre/  
navire*



Reference number  
ISO/TS 16901:2022(E)

© ISO 2022



## **COPYRIGHT PROTECTED DOCUMENT**

© ISO 2022

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

This is a preview of ISO/TS 16901:2022. [Click here to purchase the full version from the ANSI store.](#)

## Contents

|                                                                   | Page      |
|-------------------------------------------------------------------|-----------|
| <b>Foreword</b> .....                                             | <b>v</b>  |
| <b>1 Scope</b> .....                                              | <b>1</b>  |
| <b>2 Normative references</b> .....                               | <b>1</b>  |
| <b>3 Terms and definitions</b> .....                              | <b>1</b>  |
| <b>4 Abbreviated terms</b> .....                                  | <b>6</b>  |
| <b>5 Safety risk management</b> .....                             | <b>8</b>  |
| 5.1 Decision support framework for risk management.....           | 8         |
| 5.2 Prescriptive safety or risk performance.....                  | 8         |
| 5.3 Risk assessment in relation to project development.....       | 9         |
| <b>6 Risk</b> .....                                               | <b>11</b> |
| 6.1 What is risk.....                                             | 11        |
| 6.2 Safety philosophy and risk criteria.....                      | 12        |
| 6.3 Risk control strategy.....                                    | 12        |
| 6.4 ALARP.....                                                    | 12        |
| 6.5 Ways to express risk to people.....                           | 13        |
| 6.5.1 General.....                                                | 13        |
| 6.5.2 Risk contours (RC).....                                     | 14        |
| 6.5.3 Risk transects (RT).....                                    | 14        |
| 6.5.4 Individual risk (IR).....                                   | 14        |
| 6.5.5 Potential loss of life (PLL).....                           | 15        |
| 6.5.6 Fatal accident rate (FAR).....                              | 15        |
| 6.5.7 Cost to avert a fatality (CAF).....                         | 15        |
| 6.5.8 <i>F/N</i> curves (FN).....                                 | 15        |
| 6.5.9 Uncertainties in QRA.....                                   | 15        |
| <b>7 Methodologies</b> .....                                      | <b>16</b> |
| 7.1 Main steps of risk assessment.....                            | 16        |
| 7.2 Qualitative risk analysis.....                                | 16        |
| 7.2.1 HAZID.....                                                  | 16        |
| 7.2.2 Failure mode and effect analysis (FMEA).....                | 18        |
| 7.2.3 Risk matrix.....                                            | 18        |
| 7.2.4 Bow-tie.....                                                | 18        |
| 7.2.5 HAZOP.....                                                  | 20        |
| 7.2.6 SIL analysis.....                                           | 21        |
| 7.3 Quantitative analysis: consequence and impact assessment..... | 21        |
| 7.3.1 General.....                                                | 21        |
| 7.3.2 Consequence assessment.....                                 | 22        |
| 7.3.3 Impact assessment.....                                      | 24        |
| 7.4 Quantitative analysis: frequency assessment.....              | 25        |
| 7.4.1 General.....                                                | 25        |
| 7.4.2 Failure data.....                                           | 25        |
| 7.4.3 Consensus data.....                                         | 25        |
| 7.4.4 FAULT tree.....                                             | 26        |
| 7.4.5 Event tree analysis (ETA).....                              | 26        |
| 7.4.6 Exceedance curves based on probabilistic simulations.....   | 26        |
| 7.5 Risk assessments (consequence*frequency).....                 | 27        |
| 7.5.1 Risk assessment tools.....                                  | 27        |
| 7.5.2 Ad hoc developed risk assessment tools.....                 | 27        |
| 7.5.3 Proprietary risk assessment tools.....                      | 28        |
| <b>8 Accident scenarios</b> .....                                 | <b>29</b> |
| 8.1 Overview accident scenarios.....                              | 29        |
| 8.2 LNG import facilities including SIMOPS.....                   | 29        |
| 8.3 LNG export facilities.....                                    | 31        |

This is a preview of ISO/TS 16901:2022. [Click here to purchase the full version from the ANSI store.](#)

|                              |                                                          |           |
|------------------------------|----------------------------------------------------------|-----------|
| <b>9</b>                     | <b>Standard presentation of risk</b> .....               | <b>33</b> |
| <b>Annex A (informative)</b> | <b>Impact criteria</b> .....                             | <b>34</b> |
| <b>Annex B (informative)</b> | <b>Chain of events following release scenarios</b> ..... | <b>53</b> |
| <b>Bibliography</b> .....    |                                                          | <b>57</b> |

This is a preview of ISO/TS 16901:2022. Click here to purchase the full version from the ANSI store.

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, Subcommittee SC 9, *Production, transport and storage facilities for cryogenic liquefied gases*.

This second edition cancels and replaces the first edition (ISO/TS 16901:2015), which has been technically revised.

The main changes are as follows:

- reference to IGF code added to the scope;
- references updated in [Clause 2](#) and the bibliography;
- definitions added for HSE critical activity and HSE critical element.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).