

# Integrity Operating Windows

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## Introduction

In today's operating environment, it is not enough to base future inspection plans only on prior recorded/known history of equipment condition. A fundamental understanding of the process/operating conditions and resulting damage mechanisms are required in order to establish and maintain an inspection program that yields the highest probability of detecting potential damage. Inspection plans should be dynamic and account for changing process conditions and current equipment condition. A fundamental step is to frequently rationalize and align the developed degradation knowledge base of the materials of construction with the operation of the equipment, its inspection history, measured corrosion rates and known industry problems. With the move to risk based inspection programs, it is even more vital to identify and track process information that validates or might cause changes to existing inspection plans.

In order to maintain the integrity and reliability of pressure equipment in the refining and petrochemical industry, several process safety management systems are necessary. Many of those management systems are oriented toward having a rigorous inspection program, as well as all the supportive engineering activities, to maintain pressure equipment integrity and reliability.

In addition to the application of industry codes, standards, and recommended practices, a number of other PSM systems are vital to support a rigorous inspection and mechanical integrity program in order to predict/avoid/prevent pressure equipment damage/corrosion; leaks and failures; and improve reliability. Three key elements of those supporting PSM programs include:

- the establishment, implementation, and maintenance of integrity operating windows (IOW's);
- an effective transfer of knowledge about unit specific IOW's to all affected personnel; and
- an effective MOC program to identify any changes to the process or the physical hardware that might affect the integrity of pressure equipment.

In order to operate any process unit, a set of operating ranges and limits needs to be established for key process variables, to achieve the desired results (i.e. product within specification, safe operation, reliability, etc.). These limits are generally called operating limits or operating envelopes. IOW's are a specific subset of these key operating limits that focus only on maintaining the integrity or reliability of process equipment. Typically IOW's address issues that involve process variables that, when not adequately monitored or controlled, can impact the likelihood and rates of damage mechanisms, which may result in a loss of containment.

For purposes of this document, maintaining the integrity of the process unit means avoiding breaches of containment, and reliability means avoiding malfunctions of the pressure equipment that might impact the performance of the process unit (meeting its intended function for a specified time frame). In that sense, integrity is a part of the larger issue of pressure equipment reliability, since most breaches of containment will impact reliability. IOWs are those preset limits on process variables that need to be established and implemented in order to prevent potential breaches of containment that might occur as a result of not controlling the process sufficiently to avoid unexpected or unplanned deterioration or damage to pressure equipment. Operation within the preset limits should result in predictable and reasonably low rates of degradation. Operation outside the IOW limits could result in unanticipated damage, accelerated damage and potential equipment failure from one or more damage mechanisms.

Pressure equipment is generally fabricated from the most economical materials of construction to meet specific design criteria based on the intended operation and process conditions. The operating process conditions should then be controlled within preset limits (IOW's) in order to avoid unacceptable construction material degradation and achieve the desired economic design life of the assets.

One of the simplest examples of IOWs is the establishment of fired heater tube temperature limits to avoid premature rupture or unplanned replacement of the tubes. For example, heater tubes that have an API 530, 100,000 hour design temperature of 950 °F (510 °C) would have an increasingly shortened service life if operated at temperatures

above this design temperature. So when this limit (950 °F) is exceeded, operators would be directed to adjust fired heater controls to get the tube temperature back to below 950 °F (510 °C) within a preset amount of time. That limit of 950 °F (510 °C) would be an IOW limit for those fired heater tubes. At an even higher temperature, say 1025 °F (550 °C), the operator might be directed to take more immediate actions to regain control or even shut down the fired heater. As such there may be more than one IOW limit for the same process parameter (in this case fired heater tube temperature), for tracking/trending or to gain control prior to reaching a critical IOW limit. In addition, there may be more than one predefined response, depending upon the degree of exceedance of the process parameter limit.

A properly structured, efficient, and effective inspection program depends on IOW's being established and implemented to improve inspection planning and to avoid unanticipated impacts on pressure equipment integrity. Inspection plans are typically based on historic damage mechanisms and trends and are not generally designed to look for unanticipated damage resulting from process variability and upsets. Inspection plans generally assume that the next inspection interval (calculated based on prior damage rates from past operating experience) are scheduled on the basis of what is already known and predictable about equipment degradation from previous inspections. Without a set of effective and complete IOW's and feedback loop into the inspection planning process, inspections might need to be scheduled on a more frequent time-based interval just to look for anything that might potentially occur from process variability.

# Integrity Operating Windows

## 1 Purpose and Scope

**1.1** The purpose of this recommended practice (RP) is to explain the importance of integrity operating windows (IOW's) for process safety management and to guide users in how to establish and implement an IOW program for refining and petrochemical process facilities for the express purpose of avoiding unexpected equipment degradation that could lead to loss of containment. It is not the intent of this document to provide a complete list of specific IOW's or operating variables that might need IOW's for the numerous types of hydrocarbon process units in the industry (though some generic examples are provided in the text and in Annex A); but rather to provide the user with information and guidance on the work process for development and implementation of IOW's to help strengthen the Mechanical Integrity (MI) program for each process unit.

**1.2** The scope of this standard includes:

- definitions of IOW's and related terminology;
- creating and establishing IOW's;
- data and information typically needed to establish IOW's;
- descriptions of the various types of IOW's needed for process units;
- risk ranking IOW's;
- documenting and implementing IOW's;
- monitoring and measuring process variables within established IOW's;
- communication of IOW exceedances;
- reviewing, changing, and updating IOW's;
- integrating IOW's with other risk management practices;
- roles and responsibilities in the IOW work process; and
- knowledge transfer to affected personnel.

**1.3** This RP outlines the essential elements in defining, monitoring and maintaining IOW's as a vital component of integrity management (materials degradation control) and assisting in the inspection planning process, including Risk Based Inspection (RBI). Other Process Safety systems may be affected by or involved with the IOW program, including management of change (MOC), process safety information (PSI), and training. For purposes of this RP, these systems are only addressed to the extent of mentioning the integration aspects that are needed with the IOW program.

The use of this RP for its intended purpose is entirely voluntary for owner-users. There are no requirements that any organization use it. It is intended to be useful to those organizations that wish to establish and implement IOW's.

**1.4** This RP does not cover other operating windows established for normal process control for the purposes of maintaining product quality and other PSM issues including avoidance of operating error, that do not relate to control for the purpose of maintaining equipment integrity and reliability. However, IOW's should be integrated into existing systems for managing other operating variables and envelopes.