**In-service Operating, Maintenance, and Inspection Plan EXAMPLE**

The following document (SEAL-SSD-023) is provided as an example of possible layout for an In-Service Operating, Maintenance, and Inspection Plan. Specific details on required content are included in AFSPCMAN 91-710 Volume 3, Section 11.3.4.3. The Range User has the flexibility to decide on document layout and format.

As described in Volume 3, Section 11.3.4.3, the In-service Operating, Maintenance, and Inspection Plan provides a description of credible failure mechanisms, maintenance plans, refurbishment, calibration, type and frequency of inspection, just to name a few.

It is developed for unique, but frequently repeated, operations that require special or detailed safety considerations not addressed in this publication, and clarifies and provides detailed safety requirements that are particular to operating, maintenance and inspection operations. The inspection portion of the plan is intended to reduce the uncertainty of the risk associated with operating pressure equipment primarily by improving knowledge of the damage state. This knowledge may improve the predictability of the probability of failure1.

If the Range User chooses to use this template as a deliverable format, it is recommended that the Volume 3, Section 11.3.4.3 be used as a checklist for populating the existing sections and subsections, or adding new sections or subsections to the document, as needed. This In-service Operating, Maintenance, and Inspection Plan example is by no means complete; therefore the Range User should use the Volume 3, Section 11.3.4.3 as the driver for document completion.

The example tables included in this document are from Guidelines for Mechanical Integrity Systems. American Institute of Chemical Engineers. Wiley & Sons. 2006. Two tables are included, one for pressure vessels and one for piping.

1. ASME PCC-3, Inspection Planning Using Risk-Based Methods

[*The format and content presented in this example document approaches the In-service Operating, Maintenance, and Inspection Plan from an inspection/inspector perspective, as opposed to an engineering document. The purpose is to reduce documentation, duplication of efforts, and provide traceability to pertinent documentation through reference.*]

**<Company Name>**

DRAFT

**In-service Operating, Maintenance, and Inspection Plan FOR THE**

**<Title> PROGRAM**

Document Number: XXXXX

Revision X, 15 Sep 2020

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This document is meant as an example only. Detailed requirements

are included AFSPMAN 91-710 Vol 3, Section 11.3.4.3

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<Company Name>

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**Document Change History**

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[*The “change” section contains a summary of all changes to the latest edition of the In-service Operating, Maintenance, and Inspection Plan. All changes shall be highlighted using change bars or similar means of identification.*]

**Preface**

This document establishes and defines the <Company Name> Corporation In-service Operating, Maintenance, and Inspection Plan and its elements as required by AFSPMAN 91-710 [T] for the <Title> Program at Vandenberg AFB (VSFB).

<Company Name> Corporation, located at Isle of Avalon, Florida, has contracted with the USAF to launch <Title> launch vehicles from the Western Range. The <Title> launch vehicle consists of two stages. The first and second stage propellants are RP-1 and LOX.

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1. **Introduction**

This In-service Operating, Maintenance, and Inspection Plan provides for the operation, maintenance, and inspection of pressure system activities of the <Company Name> Launch Operations at Vandenberg Space Force Base (VSFB), California.

* 1. **Purpose**

The purpose of this plan is to provide details on operation, maintenance, and inspection of hazardous ground based pressure vessels and systems (PV/S), including cryogenic propellant systems, unique to all <Company Name> facilities located at VSFB. The plan is presented in tabular format for simplicity in tracking governing documents. This plan has been developed in accordance with the requirements of AFSPCMAN 91-710 paragraph 11.3.4.3. General elements of the ISIP program included are as follows:

* Development of a detailed ISIP program process model for PV/S;
* Inventory of PV/S, including audit or retrieval of the development design and manufacturing data;
* Analysis of PV/S, including auditing or analysis of development/design analysis to determine compliance with applicable Space Force requirements, and National Consensus codes and standards;
* Implementation of an In-Service Inspection Plan (ISIP) program to maintain PV/S.
	1. **Reference Documents**

[*In this section include all <Company Name> policies incorporated or referenced in the operation, maintenance and inspection plan. For example: inspection procedures, P&IDs, inspector training requirements, inspection criteria, etc.]*

* 1. **U.S. Space Force and Industry Requirements and Documents**

AFSPCMAN 91-710 Range Safety Requirements for the Eastern and Western Ranges as

tailored per launch program

[*In this section also include all applicable industry standards (i.e. ASME, API, etc.)*]

* 1. **Other Requirements**

When <Company Name>, Space Force, and other applicable documentation are in conflict on a specific issue, the more stringent requirements will apply until the conflict is resolved with <Company Name> and Space Launch Delta 30 Safety.

1. **In-service Operating, Maintenance, and Inspection Plan**

<Company Name> in-service operating, maintenance, and inspection plan is included in Appendix A. The following section provides brief discussion on the pertinent requirements of AFSPCMAN 91-710 Volume 3, Section 11.3.4.3.

The scope of the in-service operating, maintenance, and inspection plan includes all hazardous pressure vessels/systems and cryogenic propellant storage/loading systems under <Company Name> responsibility on the SLC-2W launch sites within the scope of AFSPCMAN 91-710 as tailored for <Title> Program.

Ground based hazardous pressure systems within the scope of the ISIP program are defined as follows: (AFSPCMAN 91-710 Volume 3, paragraph 1.1)

* Hazardous fluids systems (i.e. cryogens, flammables, combustibles, hypergolics,
* Systems exceeding operating pressures of 250 psig,
* Systems exceeding stored energy levels of 14,240 ft-lb., and
* Systems identified by Range Safety as safety critical.

PV/S that are not included in this program due to their low stored potential energy or inclusion in other programs (i.e. K-bottles inspected and tested under DOT requirements by the supplier) that are considered low energy and low risk, are as follows:

* Heating, ventilating and air conditioning (HVAC) systems such as steam heating or Freon cooling systems. Note that PV/S supporting HVAC systems, such as compressed air systems used for HVAC instrumentation control, are not excluded.
* Portable fire extinguishers and self-contained breathing air equipment.
* Potable water systems.
	1. **ISIP Documentation**

[*Include a brief discussion of documentation maintained and generated for PV/S systems, its location and access to SLD30 Safety personnel*. *Reference AFSPCMAN 91-710 Volume 3, paragraph 11.3.4 for guidance*. Also, include how the documentation is evaluated and maintained. ]

* 1. **Credible damage mechanisms**

*[Include a brief discussion of credible damage mechanisms. Review notes section in Appendix A, in particular Note 4 for guidance.]*

* 1. **Methods of controlling/eliminating failure mechanisms**

*[Include a brief discussion of methods of controlling/eliminating damage mechanisms. Review notes section in Appendix A, in particular Note 4 for guidance.]*

* 1. **Operating constraints**

*[Include a brief discussion of Operating constraints. Review notes section in Appendix A, in particular Note 4 for guidance.]*

* 1. **Maintenance plans**

*[Include a brief discussion of maintenance plans. Review notes section in Appendix A, in particular Note 4 for guidance. Include corrective action prioritization codes, or categories that explain a correlation of inspection discrepancies and safety related concern (i.e. Category 1: immediate safety threat; discontinue use, Category 2: may affect safety if not corrected in the short-term, implement mitigation NLT x months, etc.).]*

*[Appendix C is included as a possible approach to determining Risk Assessment Codes for prioritizing equipment.]*

* 1. **Type and frequency of inspection**

*[Include a brief discussion of type and frequency of inspections. Review notes section in Appendix A, in particular Note 4 for guidance. Include discussion on different types of ISI inspections (VT, UTT, PT, MT, IRT, etc.). Also include discussion of other inspections that may be required outside of the standard ISI.]*

* 1. **Inspection and NDE**
		1. **Inspection and NDE Planning**
		2. **Inspection and NDE implementation**

*[VTE, UTT, Others, etc.]*

* + 1. **Evaluation and Analysis – Pressure Vessels**
		2. **Evaluation and Analysis - Piping**
		3. **Safe Life Analysis**
	1. **Corrosion Control**

*[Include brief discussion on the <Title> Program corrosion control program, since corrosion is one of the major damage mechanisms on SLD30*.]

* 1. **Management of Change**

Un-reviewed changes to equipment or process have the potential of increasing safety hazards, damaging equipment, or causing unwanted chemical releases. <Title> Program Management of Change (MOC) procedure (xxx.xxx) requires that any changes to systems or facilities be reviewed and approved prior to being implemented.

[*Include brief discussion about management of change and its effects on the ISIP*.]

* 1. **Equipment Inventory**

Equipment in-service inspection inventory is included in Appendix B.

*[An inclusion of an in-service inspection inventory list in to Appendix B may not be feasible due to size; therefore, a reference to an on-line inventory is acceptable, as long as a Range Safety representative can acquire access for review. An example of an inventory list is provided in Appendix B.]*

**Appendix A In-service Operating, Maintenance, and Inspection Plan**

[*For the following tables provide a details of the plan in tabular format. A series of notes are included to explain what the plan should include, what information to provide, and the perspective from which it should be completed.*]

# A.1 Example of In-service Operating, Maintenance, and Inspection Plan for Pressure Vessels

| **Information** | **New Equipment****Design, Fabrication, and Installation** | **Inspection and Testing** | **Preventive Maintenance** | **Repair** |
| --- | --- | --- | --- | --- |
| **Example Activities and Typical Frequencies** | Activity | Frequency | Activity | Frequency | Activity | Frequency | Activity | Frequency |
| Verify equipment specifications are met:* Process design requirements
* Materials selection

Vendor/Shop qualificationEquipment design by manufacturer* Design approval by owner
* Welding/QC plan approval

Equipment fabrication InspectionDocumentation preparationInstallation/CommissioningAcceptance and turnover  | As-required for fabrication and installation | External visual inspection | 1-year maximum | Activities identified from RCM or similar work planning initiatives, such as:* Routine visual surveillance
* Process conditions monitoring/ tracking
* Process performance monitoring
 | As-required to meet preventive maintenance schedule or process monitoring needs | Equipment replacement-in-kind Unique vessel repair activities such as weld overlay, alterations, hot taps, or welding attachments to the pressure boundary PaintingInsulation/ Fireproofing repairChemical cleaningStructural support and anchoring systems repair or renewal  | As required by the condition of the equipment based on recommendations from ITPM activities or observations from normal operations |
| Thickness measurement | ½ corrosion life or 10-year maximum |
| Internal inspection | ½ corrosion life or 10-year maximum, thickness measurement suffices if corrosion rate is less than 5 mils per year |
| Additional inspections for specific degradation modes | As required by condition of equipment and rate of degradation |
| **Technical Basis for Activity and Frequency** | QA practices for pressure vessels  | Scheduled with intervals set by the results of previous activity or at fixed intervals based on inspection code (API-510 or NBIC) or jurisdictional requirements  | Company or jurisdictional requirements | Performed when indicated by failure during normal operations or by the results of ITPM activities  |
| **Sources of Acceptance Criteria** | ASME Boiler and Pressure Vessel Code, in conjunction with more stringent requirements in company engineering standards and in facility-specific or jurisdictional requirements for the pressure boundary | Acceptance criteria from inspection codes (e.g., API-510, NBIC), and/or jurisdictional requirements. Acceptance criteria for damage from specific degradation modes per API-579 | Company requirements and good engineering practices, coupled with upper and lower safe limits for process conditions as defined in the Process Safety Information (such as pressure, temperature, fluid composition, and velocity limits)  | Design and fabrication codes: ASME Boiler and Pressure Vessel Code, in conjunction with more stringent requirements in company engineering standards, facility, or jurisdictional requirements. Some jurisdictions require an ASME “R” stamp for repairs and alterations |
| **Typical Failures of Interest** | Incorrect material or weld metal, incorrect heat treatment, incorrect dimensions, misalignment or out-of-square flanges, leak during testing, weld defects, high hardness readings, use of unqualified welder or welding procedures | Distortion of pressure boundary, leakage from cracks (fatigue or environmental induced), or holes in pressure boundaryLack of grounding, and excessive corrosion of structural support and anchoring systems | Distortion of pressure boundary, leakage from cracks (fatigue or environmental induced), or holes in pressure boundaryLack of grounding, and excessive corrosion of structural support and anchoring systems  | Incorrect material or heat treatment, incorrect dimensions, misalignment or out of square flanges, leak during testing, weld defects, high hardness readings, use of unqualified welder or welding procedures |
| **Personnel Qualifications** | Company requirements, and documented skills, NDE qualifications, inspection certifications or technical training for inspection and acceptance activities | Documented qualifications, industry inspection certifications (API-510 or NBIC), or specific technical training to analyze results | Tasks usually require craft-specific skills or operator-specific skills that are addressed within their respective training programs | Welders qualified per Section IX of the ASME Code. NDE technicians qualified in appropriate techniques. Industry inspection certifications (API-510 or NBIC) or specific technical training for pressure vessel engineering |
| **Procedure Requirements**  | Written procedures describing:* Engineering standards for specification of equipment
* Project management (including hazard and design review schedules)
* Vendor qualification
* Documentation requirements
* Project acceptance and turnover requirements
 | Written procedures describing the inspection or test activity, including:* The manner, the extent, the location, and the timing for the inspection or test, and by whom
* The documentation and analysis of results
* The resolution of functions or conditions not meeting acceptance criteria
 | These activities generally do not require task-specific procedures  | Craft skill procedures for typical tasks encountered in repairs (e.g., welding, gasket installation, bolt tightening, pressure testing)Job-specific procedures developed for repairs or alterations to the pressure boundary Job-specific procedures for unique or complex repairs, or jobs with specialized technical content (e.g., retraying, modifications to internals, catalyst handling) Job-specific procedures with process engineering input for chemical cleaning  |
| **Documentation Requirements** | Company documentation requirements typically include U1 form, welding qualifications, design calculations, material certifications, QC results, heat treating records, as-built fabrication drawings, and nameplate data | Results and analysis of each inspection are documented for the life of the equipmentInspection dates are tracked and technical deferral is required for late tests with alternate means of protection to be considered. Deficient conditions are identified and resolved by the date recommended | Results are usually recorded by exception in equipment history files | Repair history is typically maintained with equipment inspection history |

**Notes:**

1. This template for an in-service inspection test and maintenance plan outlines programmatic overview and schedule for inspections at critical points within a process to ensure pedigree of the systems’ mechanical integrity. It is laid out such that critical information can be identified in tabular form through reference to organizational plans, procedures, and programs, as well as jurisdictional drivers and Consensus codes, in order to reduce duplication of documentation.
2. The template is populated with generic information. Focus should be placed on the main jurisdictional driver for in-service inspection plan being the AFSPCMAN 91-710, Volume 3, 11.3.4.3: In-service Operating, Maintenance, and Inspection Plan.
3. The purpose of the table, or plan, is to provide a quick reference to supporting material that encompass all required documentation supporting operation, maintenance and inspection of pressure systems.
4. Items of interest that should be considered when populating the table and considering the Volume 3, 11.3.4.3 requirements are as follows:
	1. Credible damage mechanisms (11.3.4.3.1): the primary credible failure mechanisms on VSFB are corrosion and mechanical damage. Other mechanisms can be identified in ASME PCC-3, which damage can be identified via surface external visual examination. This does not include manufacturing defects.
	2. Methods of controlling/eliminating failure mechanisms (11.3.4.2): operation degradations due to stress, design fabrication, installation, and operation are primarily controlled by operating design requirements, i.e. ASME design, construction and operating requirements and AISC/ASCE/IBC installation requirements; therefore, these are not considered on stream damage mechanisms. Creep and fatigue, if causes for concern, should be monitored by inspection and service history. Maintenance deficiencies are not damage mechanisms, but rather programmatic oversight issues.
	3. Operating constraints (11.3.4.3.3.1): Operating constraints are generally captured in the MSPSPS and should not be included in the table above. They should be included in tabular data of Appendix B.
	4. Maintenance plans (11.3.4.3.3.2): corrosion protection, maintenance schedule, soft-good replacement, refurbishment, calibration can be included in Section 2.4 of this document with brief discussion of program and reference to program documents (i.e. <Company Name> document xxx.xx-xx).
		1. In many cases soft-good replacement may not be a maintenance activity, whereby if a soft-good fails, then the component is replaced.
		2. Calibration/testing frequency is driven by AFSPCMAN 91-710, or as negotiated by Range User.
	5. Type and frequency of inspection (11.3.4.3.3.3): inspection frequency and type of inspection should be included in the table above for systems.
		1. New system inspection type and frequency will be similar and less invasive. Existing systems, especially recertified pressure vessel assets, may have more specific in-service inspection (ISI) requirements (i.e. RT, UTV, UTT, etc) at off-nominal intervals. For these types of assets/systems a copy and paste of the individual system ISI plan from a recertification report as an additional table to this report is sufficient.
		2. Valve and actuator in-service inspection may encompass system visual inspection and pre-launch/post-launch nominal valve function efforts (i.e. cycling valve for nominal operation, noting proper feedback signal for remotely operated valves, etc.)
5. It is recommended that consideration be focused on how the in-service inspection program will be executed. How the system(s) will be divided and physically inspected? How P&IDs are used to verify component integrity? How inspection reports are generated, reviewed, and if required, forwarded for engineering review? How anomalies, or rejectable items are remedied? One source for the development of organizing inspection programs can be found at the National Board of Boiler and Pressure Vessel Inspectors, Organizing A Vessel, Tank, and Piping Inspection Program (<https://www.nationalboard.org/index.aspx?pageID=164&ID=185>)

# A.2 Example of In-service Operating, Maintenance, and Inspection Plan for Piping

| **Attribute** | **New Equipment****Design Fabrication, and Installation** |  **Inspection and Testing**  | **Preventive Maintenance** | **Repair** |
| --- | --- | --- | --- | --- |
| Example Activities and Typical Frequencies | Activity | **Frequency** | Activity | **Frequency** | Activity | **Frequency** | Activity | **Frequency** |
| Verify design/fluid service requirements are met:* Pressure rating
* Materials selection

Fabrication Contractor Qualification* Design Approval by Owner
* Welding/QC Plan Approval

Fabrication/Storage/ShippingInstallation Acceptance Inspection and TestingDocumentation PreparationAcceptance and TurnoverCommissioning | As-required for fabrication and installation | External Visual Inspection | 1-year maximum | Activities identified from FMEA or other analysis techniques for reliability-centered maintenance, RBI or similar working planning initiatives, such as monitoring/tracking process conditions | As-required to meet PM schedule  | Piping/component replacement-in-kind Commissioning activitiesTemporary clampsHot taps/ stopples, etc.PaintingInsulation RepairCleaningSupport, hanger and anchoring systems repair or renewal  | As required by the condition of the equipment based on recommendations from the inspection and testing or PM activities. |
| Thickness Measurement Inspection | Lesser of default interval values in API 570 or ½ life based on measured wall thickness and calculated corrosion rates  |
| RBI Assessment | Adjustment of intervals and extent with RBI assessment, plan to be reviewed at default inspection intervals |
| Special Emphasis InspectionInjection point and Soil-to-Air interface | Injection Point InspectionLesser of 3 years maximum or ½ life based on measured wall thickness and calculated corrosion ratesSoil-to-Air Interface Inspection:Default interval values in API 570 |
| Technical Basis for Activity and Frequency | Quality assurance practices for piping fabrication and installation | Scheduled with intervals set by the results of previous inspection or default maximum intervals listed in the inspection code (API-570)  | Company or jurisdictional requirements | Performed when indicated by failure, by the results of PM activities, by the results of inspection and testing activities  |
| Acceptance Criteria | B31.x codes for piping design and fabrication and in conjunction with more stringent requirements in Company Engineering Standards, or facility-specific standards  | Acceptance criteria from inspection codes API-570 or jurisdictional requirements. Acceptance criteria for damage from specific degradation modes per API-579 | Upper and lower safe limits for process conditions defined in the Process Safety Information, such pressure, temperature, fluid composition, and velocity | B31.x Design and Fabrication Code: in conjunction with more stringent requirements in Company Engineering Standards, facility or jurisdictional requirements |
| Typical Failures of Interest | Dimensional errors, incorrect material or weld metal, incorrect dimensions, misaligned or out of square flanges, incorrect pressure rating for a component, leak during testing, weld defects outside of acceptance criteria, high hardness readings, use of unqualified welder or welding procedures  | Leakage from cracks, internal or external corrosion, excessive vibration. unsupported or bound piping, permanent distortion, piping component not meeting pressure rating  | Process conditions exceed safe upper or lower limit | Dimensional errors, incorrect material or weld metal, incorrect dimensions, misaligned or out of square flanges, incorrect pressure rating for a component, leak during testing, weld defects outside acceptance criteria, high hardness readings, use of unqualified welder or welding procedure, leakage during hot tap/stopple operations, inability to remove hot tap/stopple machines |
| Personnel Qualifications | Company requirements, and documented craft skills for installation, NDE qualifications, and ASME Section IX welding requirements for welders  | Documented NDE qualifications, industry inspection certifications (API-570), or specific technical training for piping engineering for analysis of results. | Operator training | Welders qualified per ASME Section IX Code, NDE technicians qualified to appropriate techniques, industry inspection certifications (API-570), or specific technical training for storage tank engineering |
| Procedure Requirements  | Written procedures describing:- Engineering standards for specification of equipment- Project management (including hazard and design review schedules)- Vendor qualification- Documentation requirements - Project acceptance and turnover requirements | Written procedures describing the inspection or test activity, including:1. -The manner, the extent, the location, and the timing for the inspection or test, and by whom
2. -The documentation and analysis of results
3. -The resolution of functions or conditions not meeting acceptance criteria
 | Operating procedures | Craft skill procedures for typical tasks encountered in repairs such as welding, gasket installation and bolt tighteningJob-specific procedures developed for repairs or alterations to the pressure boundary Job specific procedures for unique or complex repairs, or jobs with specialized technical content such as line lifting, hot taps, stopples, and clamp installationsJob specific procedures with process engineering input for chemical cleaning  |
| Documentation Requirements | Company documentation requirements typically include: Welding qualifications, weld map, design calculations, material certifications, QC results, and as-built drawings, pressure test report  | Results and analysis of each inspection are documented for the life of the equipmentInspection dates are tracked and technical deferral required for late tests with alternate means of protection to be considered. Deficient conditions are identified and resolved by the date recommended. | Results are usually recorded by exception in the equipment history file | Repair history is maintained with equipment inspection history |

**Notes:**

1. Notes from Pressure Vessel plan from section A.1 also apply to this table.

**Appendix B In-service Inspection Equipment Inventory List**

[*An inclusion of an in-service inspection inventory list may not be feasible due to size; therefore, a reference to an on-line inventory is acceptable, as long as a Range Safety representative can acquire access for review. An example of an inventory list is provided below.]*

**Appendix C Risk Assessment Code Determination (RAC)**

[*Describe RAC methodology for categorizing PV/S criticality. One possible approach is to use NASA-STD-8719.17C, NASA Requirements for Ground-Based Pressure Vessels and Pressurized Systems (PVS), as it is specific to PV/S. This RAC system can then be correlated to the corrective action prioritization codes of Section 2.5 to assist in scheduling maintenance*.]