# Preparation of an Operation & Configuration Control Plan (OCCP) for "Category B" Pressure Vessels/Systems (PV/S)

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# Preparation of an Operation & Configuration Control Plan (OCCP) for "Category B" Pressure Vessels/Systems (PV/S)

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## 1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the requirements and methodology for preparation of an Operation & Configuration Control Plan (OCCP) as required by JPR 1710.13E to assure safe ground pressurization and pressurization during aircraft operations of "Category B" flight or flight-like Pressure Vessels/Systems (PV/S) at Johnson Space Center (JSC), Ellington Field and associated NASA space-flight/aircraft operations facilities.

An OCCP is a written assessment showing that a "Category B" flight or flight-like PV/S is safe for ground pressurization and pressurization during aircraft operations, within the bounds established by the OCCP.

## 2.0 SCOPE

This procedure applies to OCCP preparation for all "Category B" PV/S defined by JPR 1710.13E. An OCCP is required prior to ground pressurization and pressurization during aircraft operations of "Category B" PV/S.

## 3.0 REFERENCES

The following references may apply to operation and design of "Category B" PV/S. The PV/S hardware developer (HD) should be familiar with these references. Such familiarization shall allow for more effective interaction between the HD and Materials and Processes Branch (ES4), the JSC organization tasked with review and approval of OCCPs, during PV/S assessment.

3.1 JPR 1710.13E, "Design, Inspection, and Certification of Ground-Based Pressure Vessels and Pressurized Systems"

3.2 ANSI/AIAA S-080-1998; Space Systems - Metallic Pressure Vessels, Pressurized Structures, and Pressure Components

3.3 ANSI/AIAA S-081A-2006; Space Systems - Composite Overwrapped Pressure Vessels (COPVs)

3.4 NSTS 1700.7B, "Safety Policy and Requirements for Payloads Using the Space Transportation System"

## 4.0 DEFINITION OF TERMS

**Nominal Operating Pressure:** The pressure at which the PV/S operates during normal conditions. The nominal pressure is established by the HD.

**Maximum Operating Pressure (MOP):** The maximum pressure at which the PV/S could operate in a particular application. MOP includes the effects of temperature, transient peaks, vehicle acceleration, and relief valve tolerance. *MOP is synonymous with "Maximum Expected Operating Pressure (MEOP)."* The MOP is established by the HD and program.

**Maximum Design Pressure (MDP):** The highest possible operating pressure considering maximum temperature, maximum relief valve/regulator tolerant pressure, and, where applicable, transient pressure excursions. MDP for manned space-flight PV/S is collectively two fault tolerant pressure, i.e., it shall accommodate any worst combination of two credible failures of the relief valve and/or the regulator. MDP also accommodates the maximum temperature to be experienced in the event of Transatlantic Abort Landing (TAL) of the Space Shuttle without cooling facilities. The MDP is established by the HD and program.

**Maximum Allowable Working Pressure (MAWP):** The maximum pressure at which a PV/S can continuously operate based on allowable stress values and functional capabilities. *MAWP is synonymous with "Rated Pressure"* and is typically available through the manufacturer's specification.

**Burst Pressure:** The burst pressure is the ultimate test pressure at which the PV/S ruptures in a qualification test and is typically available through the manufacturer's specification.

**Proof Pressure:** An acceptance pressure test to verify structural integrity of PV/S which is in excess of MOP or MDP by a defined factor, known as proof factor.

**Factor of Safety (FOS)**: The burst pressure divided by the MOP or MDP. If the burst pressure is not available, the MAWP may be used in place of burst pressure.

## 5.0 RESPONSIBILITIES

ES4 of the Structural Engineering Division (SED) is responsible for safe operation of flight and flight-like PV/S when pressurized at JSC, Ellington Field and associated NASA space-flight/aircraft operations facilities. Delegation of responsibility is exercised through the JSC Pressure Systems Manager's Office (PSMO) by means of an OCCP that provides information, guidelines, and requirements for assurance of safe pressurization during ground testing and pressurization during aircraft operations of "Category B" PV/S. Safety of all other categories of PV/S and ground support equipment (GSE) is the responsibility of the PSMO within the Safety & Mission Assurance ((S&MA) organization.

It is the responsibility of the PV/S HD developer to provide ES4 with system and part data sufficient for safety assessment of the system and preparation of the OCCP. This information must include, but is not necessarily limited to, the information identified in Section 7.0 (Information Requirements). ES4 shall verify that the system meets the requirements of references 3.2 through 3.4, as applicable.

## 6.0 PERSONNEL TRAINING AND CERTIFICATION

Formal and informal training is required for OCCP approval. Engineering experience and a technical/science degree (Bachelor of Science minimum) with a minimum of one year experience with the design and safety of space-flight pressurized systems is required. Training in the procedural aspects of materials applications and fracture control methodology and certification, including knowledge of the specific responsibilities and activities of personnel and programs involved, is also required. In addition, familiarity with the referenced documents and the general design and safety requirements for ground, aircraft operations and space-flight systems is required. Systems submitted for OCCPs must have a lead engineer with experience in pressurized systems design, standards, assembly and testing procedures.

## 7.0 INFORMATION REQUIREMENTS

This section identifies the information needed that is used to prepare an OCCP. It is recognized that some data may not be available or known. However, adherence to the information order and content outlined below shall facilitate processing of OCCP requests.

1. **Statement of purpose**
   For what purpose is this OCCP being requested (e .g. proof pressure test, leak test, operational test, combination, etc.)?

2. **Test location**
   Where shall the pressurization take place?

3. **System description**
   Is the system flight or flight-like or experimental?
   What is the system designed to do?

4. **Pressure history**
   What historical documentation exists for the system, or for parts of the system?
   Is a pressure or service history available?

5. **Description of system fluid(s)**
   What is the system fluid? Toxic or flammable fluid may require addition assessment.
   Is the fluid toxic or flammable?
   What nominal and worst case temperatures might the fluid experience?
   What materials are compatible with the test fluid?

6. **Schematic diagram**
   Provide a schematic of the system showing:
   - Hardware arrangement
   - Reference designation

- Test pressures
- Interfaces with facility hardware

*Figure 1 on page 12 provides an example of PV/S schematics.*

**7. Detailed drawings**

Include any detailed drawings available for the system along with 3D Computer-Aided Design (CAD) schematics of a pressure system.

*Figure 2 on page 14 provides an example of 3D CAD schematics of a PV/S*

**8. Maximum Operating Pressure (MOP)/Maximum Design Pressure (MDP)**

What is the system's MOP or MDP?
How was the MOP or MDP established?
*(MOP or MDP includes the effects of temperature, transient peaks, vehicle acceleration and relief valve tolerance as described in section 4.0)*
What failure scenario led to determination of the MOP?
Is this at least a two-fault tolerant scenario against MDP?
What faults were assumed?

**9. Component matrix**

For each pressurized part in the system (pressure vessels, lines, fittings and components, etc.), outline the following in matrix form:

- Reference designation
- Manufacturer's name and part number
- Material of construction (Liner, overwrap and resin)
- Assembly method (i.e., welds, braze, compression fitting, coupling, etc.)
- System fluid(s)
- Operating temperature ranges
- Nominal operating pressure (refer to section 4.0 for definition)
- MOP or MDP (refer to section 4.0 for definition)
- MAWP or pressure rating (refer to section 4.0 for definition)
- Actual burst pressure (refer to section 4.0 for definition)
- Factor of safety (FOS) on burst (Ratio of Burst Pressure and MOP or MDP) (refer to section 4.0 for definition)
- Pressure at which the leak test is performed
- Proof pressure test factors (refer to section 4.0 for definition)

*Table 1 on page 13 provides an example of PV/S data table for component matrix.*

**10. Test procedures**

Include any written procedures available that describe the pressurization and operation activities planned for the system. Written procedures are required prior to pressurization.

**11. Fracture/stress analyses**

Include any fracture and/or stress analyses that may have been completed for the system.

**12. Date required**

When is the OCCP needed?

**13. Pressure System Managers Office (PSMO) involvement**

Has the PSMO been contacted regarding this PV/S?
Is any pressurized ground support equipment or other facility pressure systems that might interface with this PV/S currently certified?
Is there any pressure equipment planned for use that is not either covered by the PSMO or within the planned OCCP?

**14. Personnel involvement**

Who, besides the PSMO is to be included on the distribution of this OCCP (i.e. project managers, project and safety engineers, etc.)?

**15. Safety review panel involvement**

Has the Payload Safety Review Panel (PSRP), Space Station Review Panel (SRP), or Flight Equipment Safety and Reliability Review Panel (FESRRP) assessed this PV/S for flight safety? If so, please include reference to the Safety Data Package (SDP).

**16. Relief Valves**

Analyses shall be provided to show that the maximum pressure surge downstream of a cracked relief valve shall not exceed the MAWP of the components downstream of the relief valve. Relief valves are typically installed immediately downstream of a regulator to protect components from a failed open regulator. Certified set pressure test data from the relief valve vendor or the NASA Cal Lab shall be provided to show the cracking and reseat pressures.

**17. Special considerations**

Are there any special components or system hardware that deserves special attention?
If any welds or brazes exist in the PV/S, did certified personnel make them?
Were the welds or brazes proof pressure tested and/or examined by non-destructive testing (NDT)?
Is there any weld consideration that could results in increased localized discontinuity stresses due to welding peaking and/or mismatching which can significantly alter the static strength and service life capability (cycles to failure, critical crack size, leak-before-burst (LBB), etc.)?
Does the PV/S contain a Composite Overwrapped Pressure Vessel (COPV)?
Does a damage control plan (DCP) exist to evaluate and mitigate defined threats to a COPV?
Does the Project plan to inspect the COPV by a qualified inspector before adding the protective sleeve/cover or closing the lid of the panel as a part of proper damage control?

## 8.0 PROCEDURE

OCCPs for "Category B" PV/S are approved by ES4, but may be prepared by others at their discretion. At a minimum, an OCCP must have an identifying title, an identifying memo number and an issue date furnished by ES4. Content of the OCCP must basically embody the following sections in a simple format.

**A. Purpose:** This section states why the OCCP is written and can be standardized as: "The purpose of this plan is to define the basic requirements and procedures in compliance with JSC Management Instruction 8833.2B and JPR 1710.13E to assure safe ground pressurizations and pressurization during aircraft operations of flight or flight-like ("Category B") PV/S."

**B. Applicability:** The specific applicability of the OCCP must be established. The applicability shall address a specific PV/S covered by the OCCP. This defines the bounds of the "Category B" PV/S covered by the OCCP to differentiate it from associated pressure hardware that may fall into other categories.

**C. Hardware Description:** This section must provide information of the PV/S being covered by the OCCP. A brief physical description and major components such as pressure vessels, regulator, relief valve, high pressure lines, etc. should be listed in this section. The description should be sufficient to establish general configuration and pressure capability of the hardware.

**D. Assessment:** This section should summarize assessment/analysis considered for the OCCP as pertinent to system safety. This includes consequence(s) of failure, MOP or MDP evaluation, FOS verification, LBB and/or damage tolerant assessment, proof pressure test and/or leak check factors and configurations, and any other analyses used to generate the OCCP.

**E. Requirements:** Specific requirements necessary to comply with the intent of JPR 1710.13E and to assure safe operation of "Category B" PV/S in ground tests and pressurization during aircraft operations are to be specified in this section. These requirements are developed during the review of the information supporting the OCCP. The following are examples of requirements that might be listed:

1. Approved written procedures shall be generated and followed for all operations involving pressurization and/or personnel exposure to pressurized hardware.

2. A test plan and/or associated procedures shall be defined for safe handling of the hardware during ground preparation, installation in the aircraft, flight, and recovery.

3. All safety procedures normally implemented during pressurization activity shall be upheld and only persons familiar with the hardware shall be permitted to interface with it during pressurization.

4. Only water, pure air, helium, or nitrogen gases may be contained in the PV/S when pressurized for ground tests and pressurization during aircraft operations. Pressurizations in excess of 500 psi shall be accomplished without direct personnel exposure.

5. Any limitation on the pressure cycles to maximum operating pressure that may be safely applied to the vessels.

6. Statement on proof pressure test and visual examination of the PV/S for indications of damage prior to the Test Readiness Review (TRR) on the OCCP. In the event that any limitation or requirement of the OCCP is violated after the TRR, the occurrence shall be immediately brought to the attention of ES4 prior to re-pressurization on the ground, for flight, or re-flight.

7. A Damage Control Plan (DCP) to evaluate and mitigate defined threats to a COPV shall be documented by the Project and maintained in the Safety Data Package (SDP).

8. Inspection of a composite overwrapped pressure vessel (COPV) by a qualified inspector before adding the protective sleeve/cover or closing the lid of the panel as a part of proper damage control shall be addressed in the OCCP. If the COPV or the protective sleeve/cover or lid of the panel is removed on a later date, or if any damage is suspected due to impact, improper pressurization, etc, the COPV shall be re-inspected by a qualified inspector. An inspector may be considered a qualified inspector who completes damage detection training program offers by White Sands Test Facility (WSTF), Department of Transportation (DOT), Natural Gas Vehicle Institute (NGVi) or equivalent.

9. No modifications or changes shall be made to the pressure system after the TRR without ES4 approval prior to ground and/or flight pressurization.

8. Permanent records including signed OCCP, COPV Inspection Report, DCP, signed TRR, analyses, tests, pressurization histories, anomaly reviews, and any other information pertinent to performance of the PV/S shall be maintained by the appropriate program office at all times.

9. In the event that any limitation or requirement of this plan is violated the occurrence shall be immediately brought to the attention of the PSMO and evaluated by ES4 as necessary.

## 9.0 REVIEWS & RECORDS

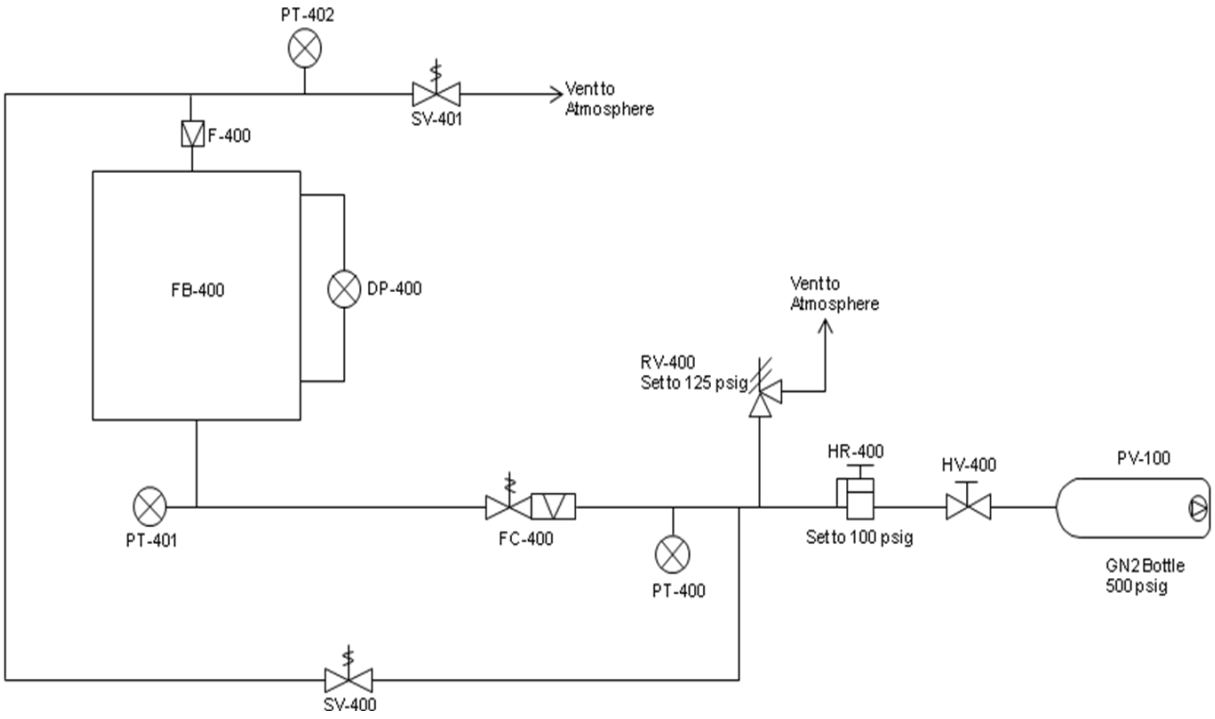
All OCCPs shall be reviewed and approved by ES4. A copy of each approved OCCP for specific hardware shall be furnished to the HD and the PSMO prior to pressurization of "Category B" PV/S. ES4 shall maintain records of individual OCCPs as long as the affected "Category B" PV/S remains at JSC or if it is returned to JSC, even if not part of an active test program.

## 10.0 ACRONYM

| | |
|---|---|
| ANSI | American National Standards Institute |
| AIAA | American Institute of Aeronautics and Astronautics |
| CAD | Computer-Aided Design |
| COPV | Composite Overwrapped Pressure Vessel |
| DCP | Damage Control Plan |
| DOT | Department of Transportation |
| ES4 | Materials & Processes Branch |
| FESRRP | Flight Equipment Safety and Reliability Review Panel |
| FOS | Factor of safety |
| GSE | Ground Support Equipment (GSE) |
| HD | Hardware Developer |
| JSC | Johnson Space Center |
| JPR | Joint Program Review |
| LBB | Leak-Before-Burst |
| MAWP | Maximum Allowable Working Pressure |
| MDP | Maximum Design Pressure |
| MEOP | Maximum Expected Operating Pressure |
| MOP | Maximum Operating Pressure |
| NASA | National Aeronautics and Space Administration |
| NDT | Non-Destructive Testing |
| NGVi | Natural Gas Vehicle Institute (NGVi) |
| NSTS | National Space Transportation System |
| OCCP | Operation & Configuration Control Plan |
| PSMO | Pressure Systems Managers Office |
| PSRP | Payload Safety Review Panel |
| PV/S | Pressure Vessel/System |
| SDP | Safety Data Package |
| SED | Structural Engineering Division |
| SOP | Standard Operation Procedure |
| S&MA | Safety & Mission Assurance |
| SRP | Space Station Review Panel |
| TAL | Transatlantic Abort Landing |
| TRR | Technical Readiness Review |
| WSTF | White Sands Test Facility |

*For Reference Purpose Only*

**Figure 1. Pressure System Schematics**



***For Reference Purpose Only***

**Table 1. Pressure System Data Table for Component Matrix**

| Reference | Description | Manufacturer | Part Number | Operating Temp °F | Service Fluid | Nominal Operating Pressure psig | MOP or MDP† psig | MAWP psig | Burst Pressure psig | Leak Pressure psig | Proof Pressure psig |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PV-100 | Metallic Pressure Vessel | Luxfer | Add part # | 65 to 95 | $N_2$ Gas | 500 | 500 | 2000 | 7600 | DOT Cert | DOT Cert |
| HV-400 | Ball Valve | Hook | Add part # | 65 to 95 | $N_2$ Gas | 500 | 500 | 1500 | 5000 | 1.0 x MOP | 1.5 x MOP |
| HR-400 | Regulator | Tescom | Add part # | 65 to 95 | $N_2$ Gas | 500 | 500 | 1200 | 4600 | 1.0 x MOP | 1.5 x MOP |
| RV-400 | Relief Valve | Generate | Add part # | 65 to 95 | $N_2$ Gas | 100 | 500 | 1800 | 7000 | 1.0 x MOP | 1.5 x MOP |
| PT-400 | Pressure Gauge | Cecomp | Add part # | 65 to 95 | $N_2$ Gas | 100 | 125 | 1000 | 4000 | 1.0 x MOP | 1.5 x MOP |
| PT-401 | Pressure Transducer | FGP | Add part # | 65 to 95 | $N_2$ Gas | 100 | 125 | 1200 | 4500 | 1.0 x MOP | 1.5 x MOP |
| PT-402 | Pressure Transducer | FGP | Add part # | 65 to 95 | $N_2$ Gas | 100 | 125 | 1200 | 4500 | 1.0 x MOP | 1.5 x MOP |
| FC-400 | Flow Controller | Alicat | Add part # | 65 to 95 | $N_2$ Gas | 100 | 125 | 400 | 1500 | 1.0 x MOP | 1.5 x MOP |
| FB-400 | Fluidized Bed | NASA | Add part # | 65 to 95 | $N_2$ Gas | 100 | 125 | 600 | 2500 | 1.0 x MOP | 1.5 x MOP |
| DP-400 | Delta Pressure Transducer | Dwyer | Add part # | 65 to 95 | $N_2$ Gas | 100 | 125 | 900 | 3400 | 1.0 x MOP | 1.5 x MOP |
| F-400 | Filter, Parker | Parker | Add part # | 65 to 95 | $N_2$ Gas | 100 | 125 | 1000 | 4000 | 1.0 x MOP | 1.5 x MOP |
| SV-400 | Solenoid Valve | Parker | Add part # | 65 to 95 | $N_2$ Gas | 100 | 125 | 1100 | 4350 | 1.0 x MOP | 1.5 x MOP |
| SV-401 | Solenoid Valve | Parker | Add part # | 65 to 95 | $N_2$ Gas | 100 | 125 | 1100 | 4350 | 1.0 x MOP | 1.5 x MOP |

† MOP or MDP is established by the HD and program. Refer to Section 4.0 for MOP or MDP definition.

Note: All Tubing is ¼" A269 304L SS, 0.035" thickness and having MAWP > 1000 psi; No flex hose used in this application.

*For Reference Purpose Only*

**Figure 2. Example of 3D CAD Schematics of PV/S**