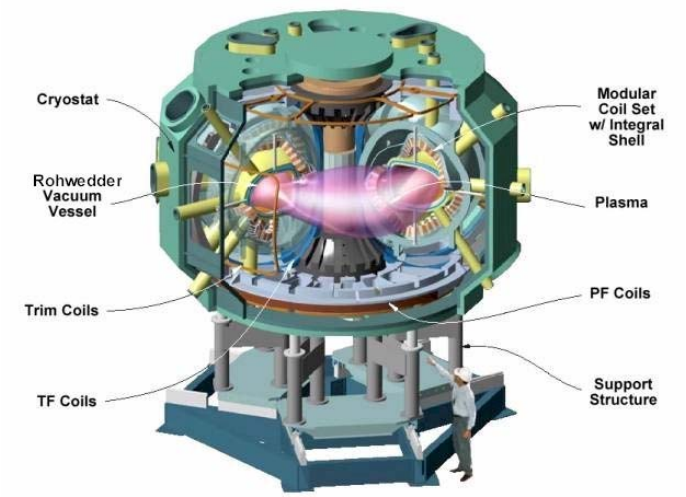
Rohwedder

NVSI

Princeton University
Plasma Physics Laboratory

National Compact Stellarator Experiment (NCSX)

Vacuum Vessel Manufacturing Development and Prototype Fabrication



3.1.3 Preliminary MIT and QA Plans for the VVSA

In Reference to Section 3.1.3 of NCSX-SOW-121-01-01

National Compact Stellarator Experiment (NCSX)

Vacuum Vessel Manufacturing Development and Prototype Fabrication

3.1.3 Preliminary MIT and QA Plans for the VVSA In Reference to Section 3.1.3 of NCSX-SOW-121-01-01

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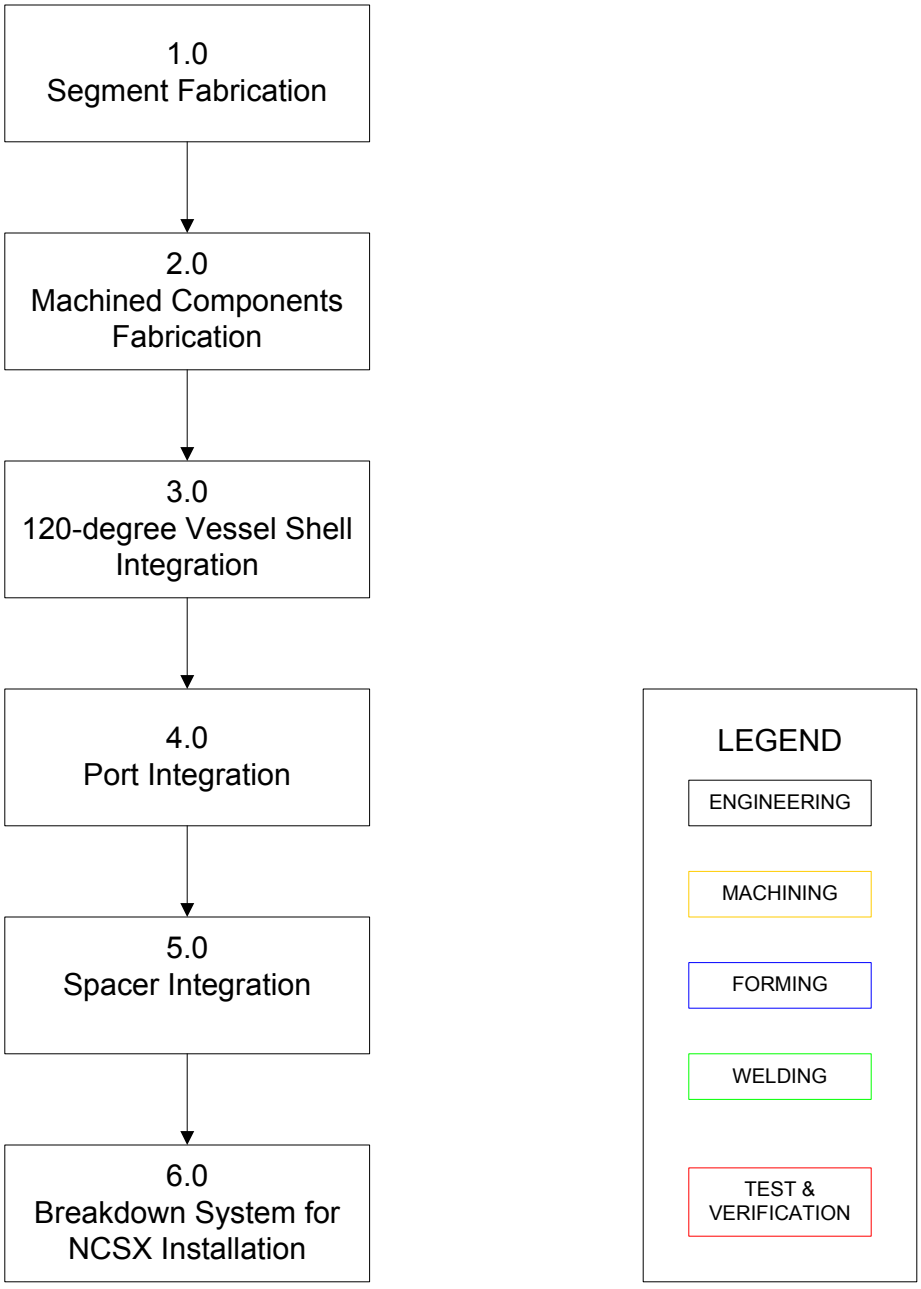
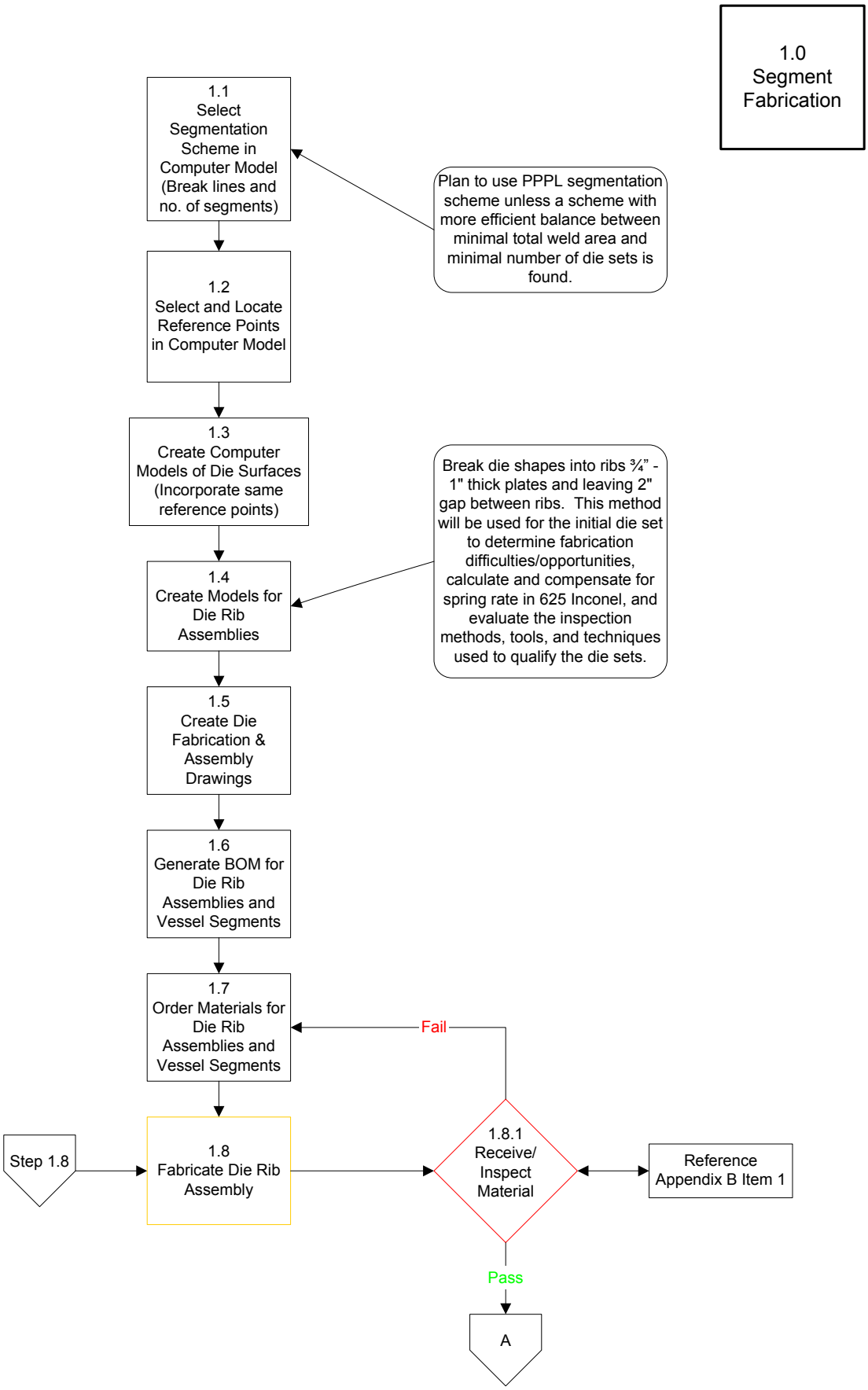
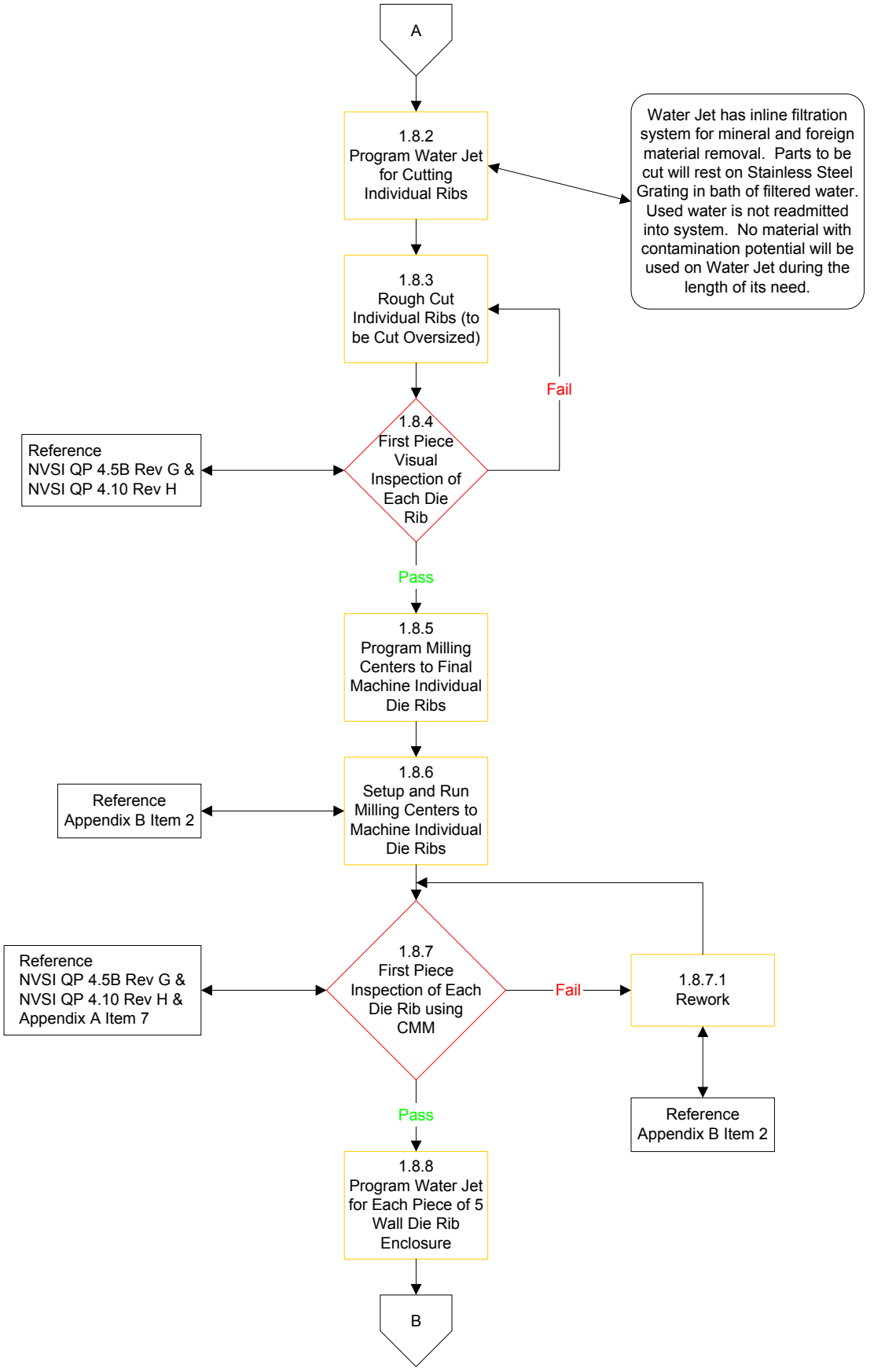
3.1.3 Preliminary MIT and QA Plans for the VVSA




1.0
Segment
Fabrication
1.1
Select
Segmentation
Scheme in
Computer Model
(Break lines and
no. of segments)
Plan to use PPPL segmentation scheme unless a scheme with more efficient balance between minimal total weld area and minimal number of die sets is found.
1.2
Select and Locate
Reference Points
in Computer Model
1.3
Create Computer
Models of Die Surfaces
(Incorporate same
reference points)
Break die shapes into ribs ¾" - 1" thick plates and leaving 2" gap between ribs. This method will be used for the initial die set to determine fabrication difficulties/opportunities, calculate and compensate for spring rate in 625 Inconel, and evaluate the inspection methods, tools, and techniques used to qualify the die sets.
1.4
Create Models for
Die Rib
Assemblies
1.5
Create Die
Fabrication &
Assembly
Drawings
1.6
Generate BOM for
Die Rib
Assemblies and
Vessel Segments
1.7
Order Materials for
Die Rib
Assemblies and
Vessel Segments
Fail
Step 1.8
1.8
Fabricate Die Rib
Assembly
1.8.1
Receive/
Inspect
Material
Reference
Appendix B Item 1
Pass
A

1.0
Segment
Fabrication



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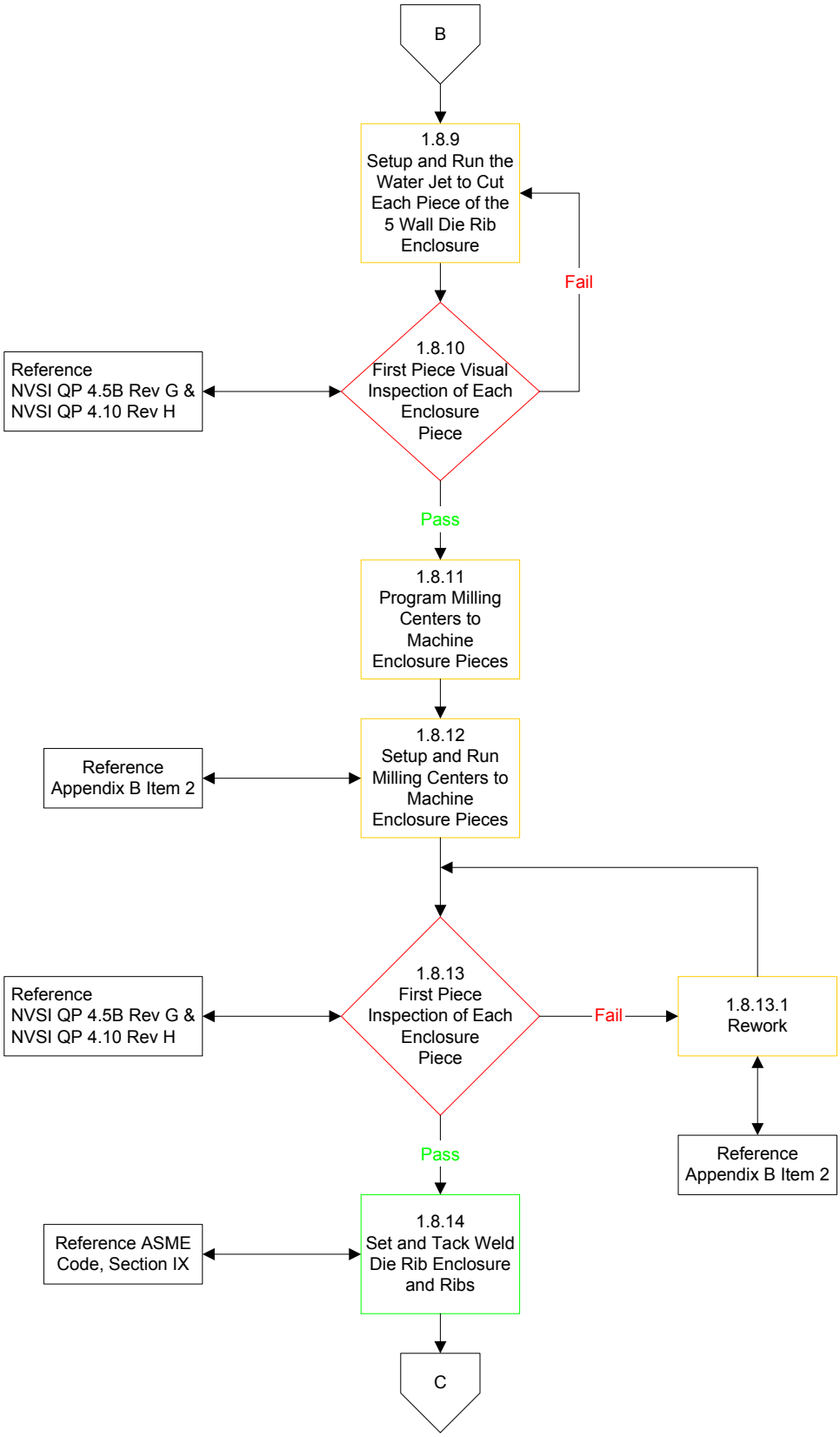
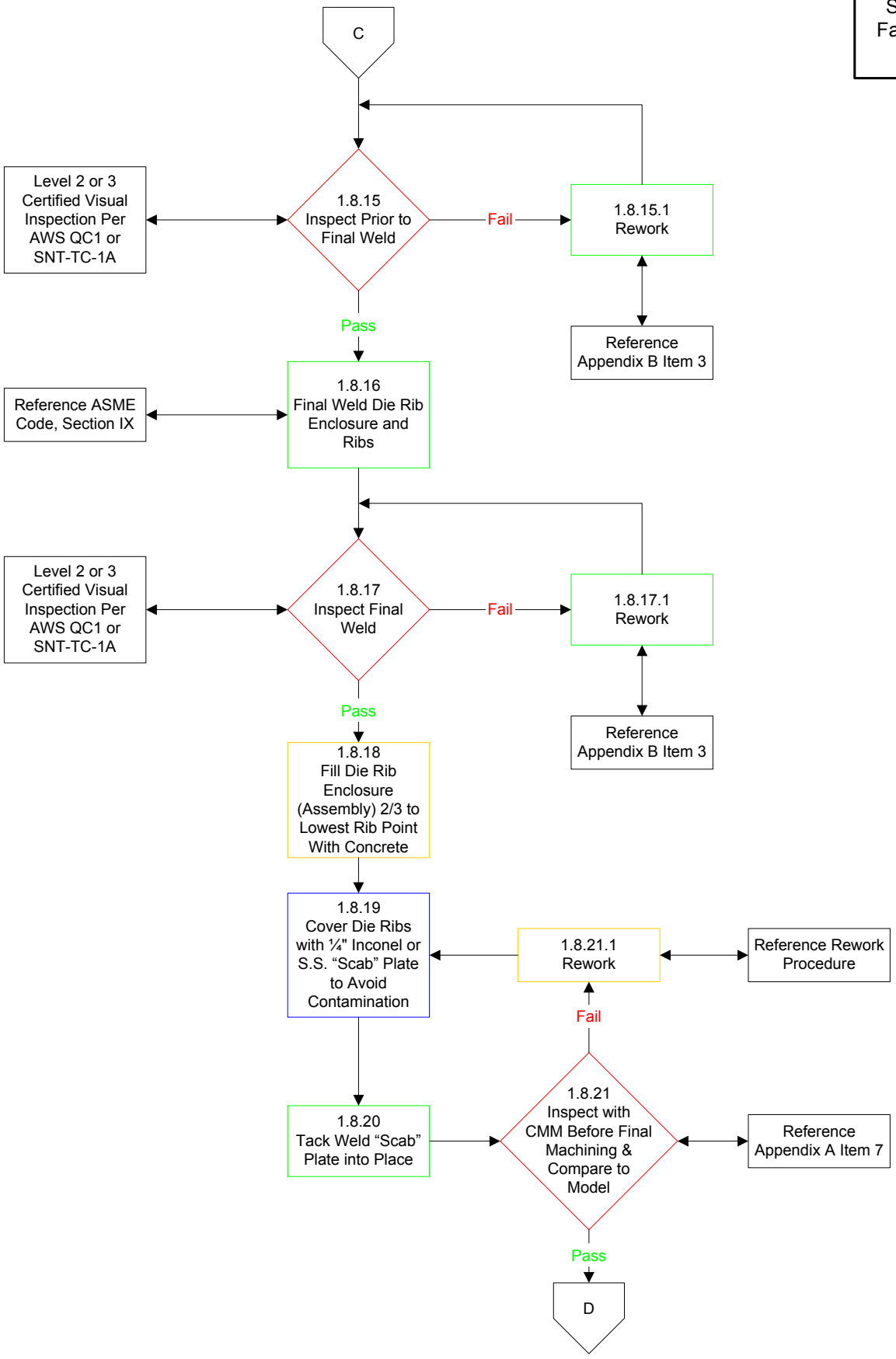
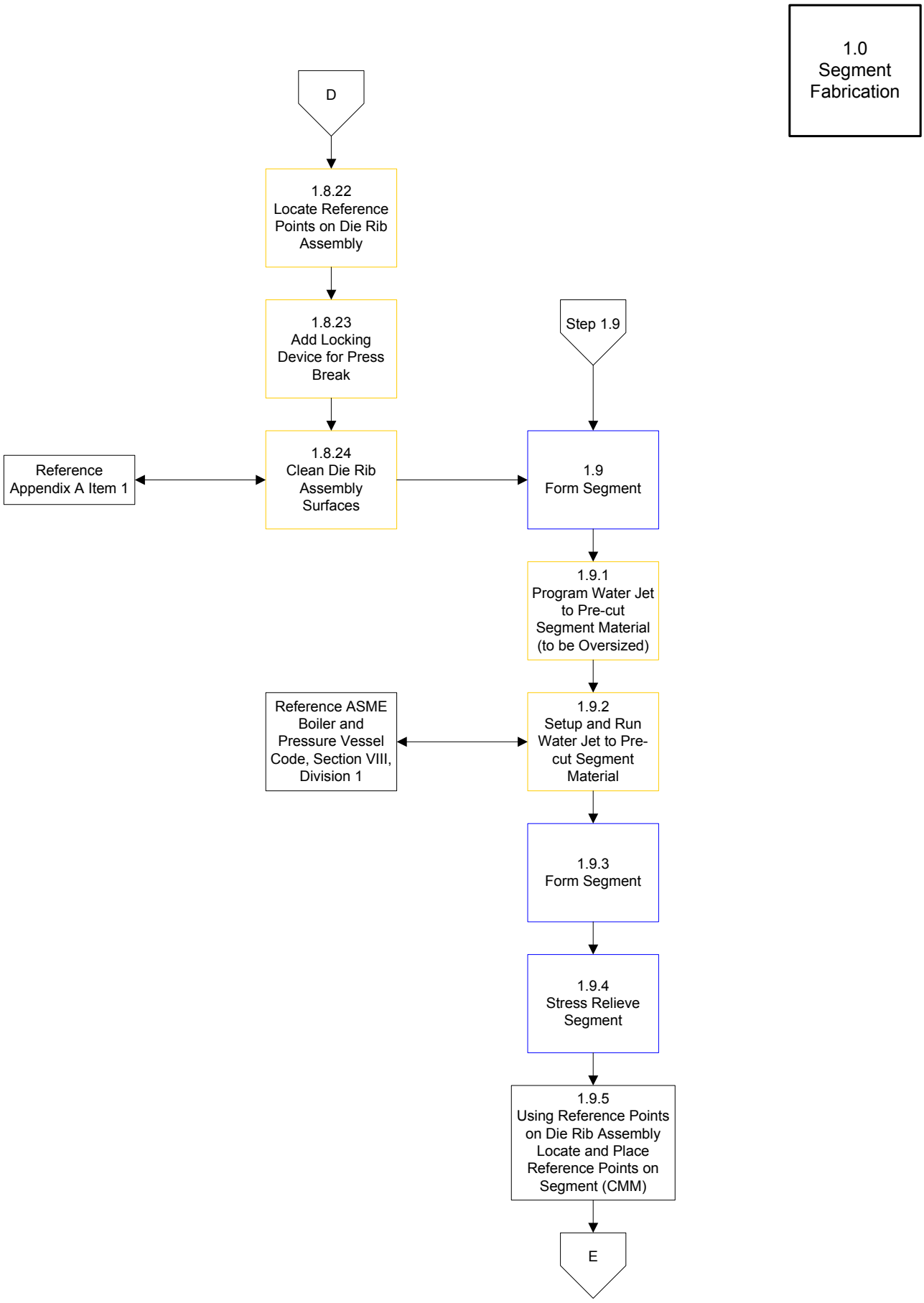
Segment
Fabrication

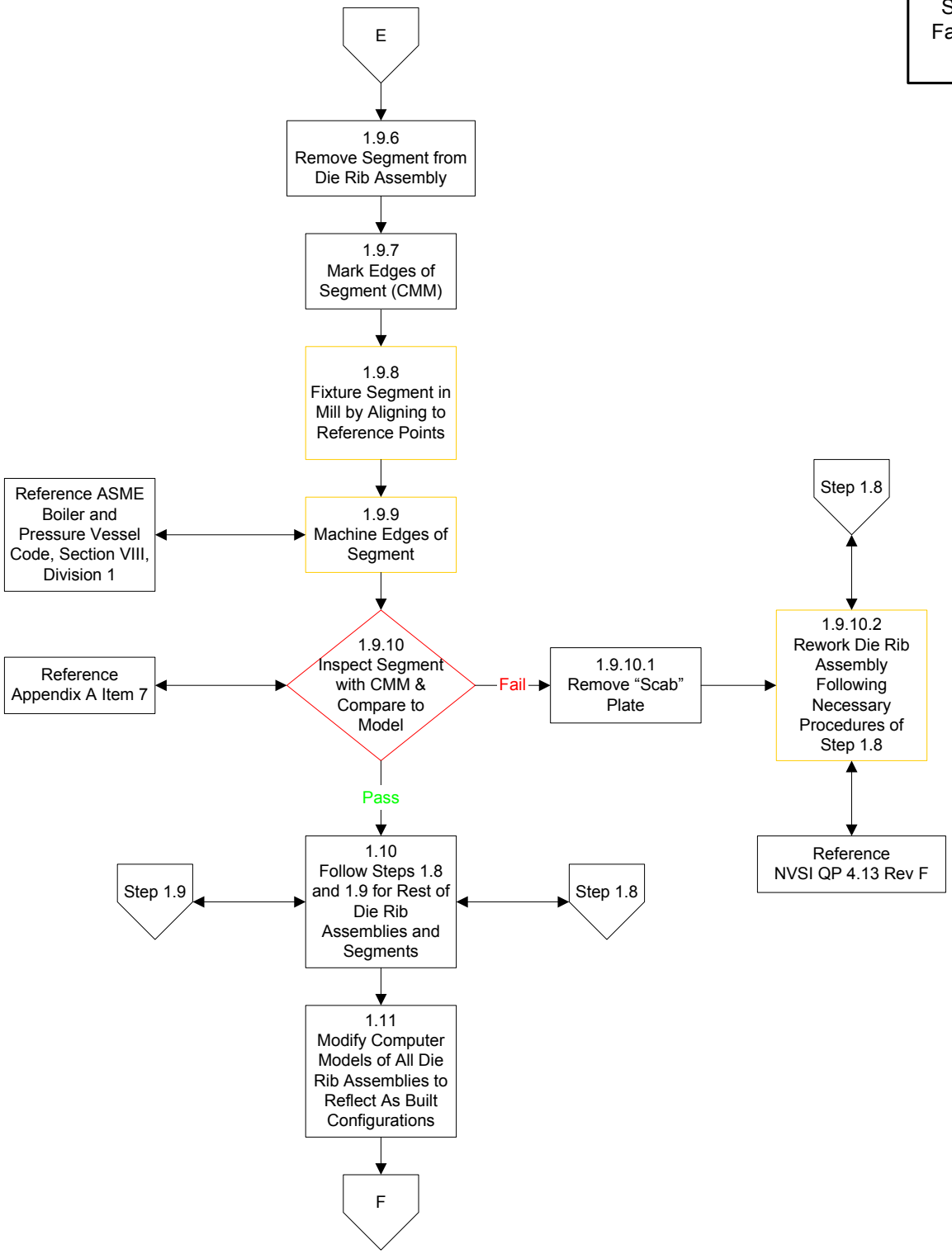


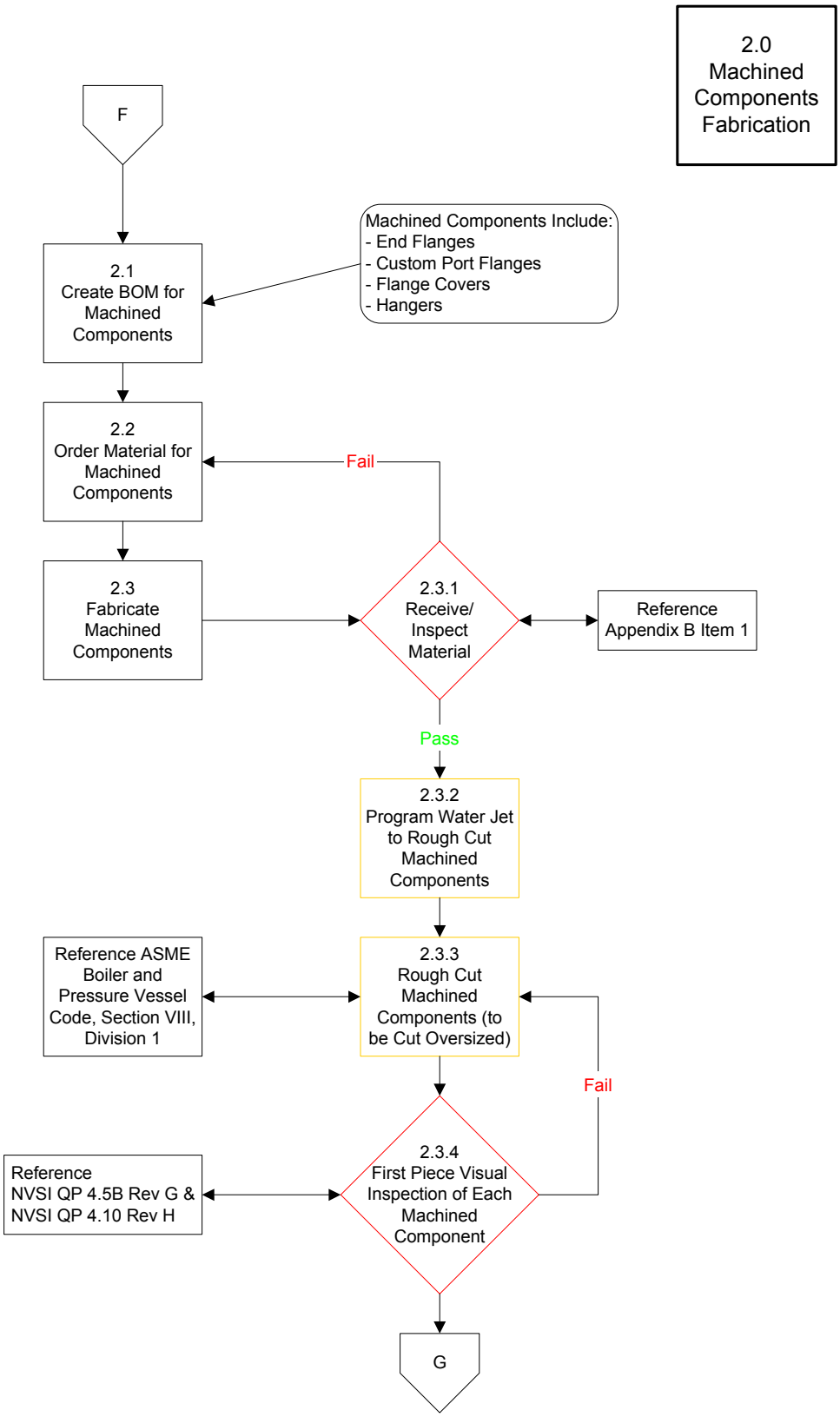
1.0
Segment
Fabrication



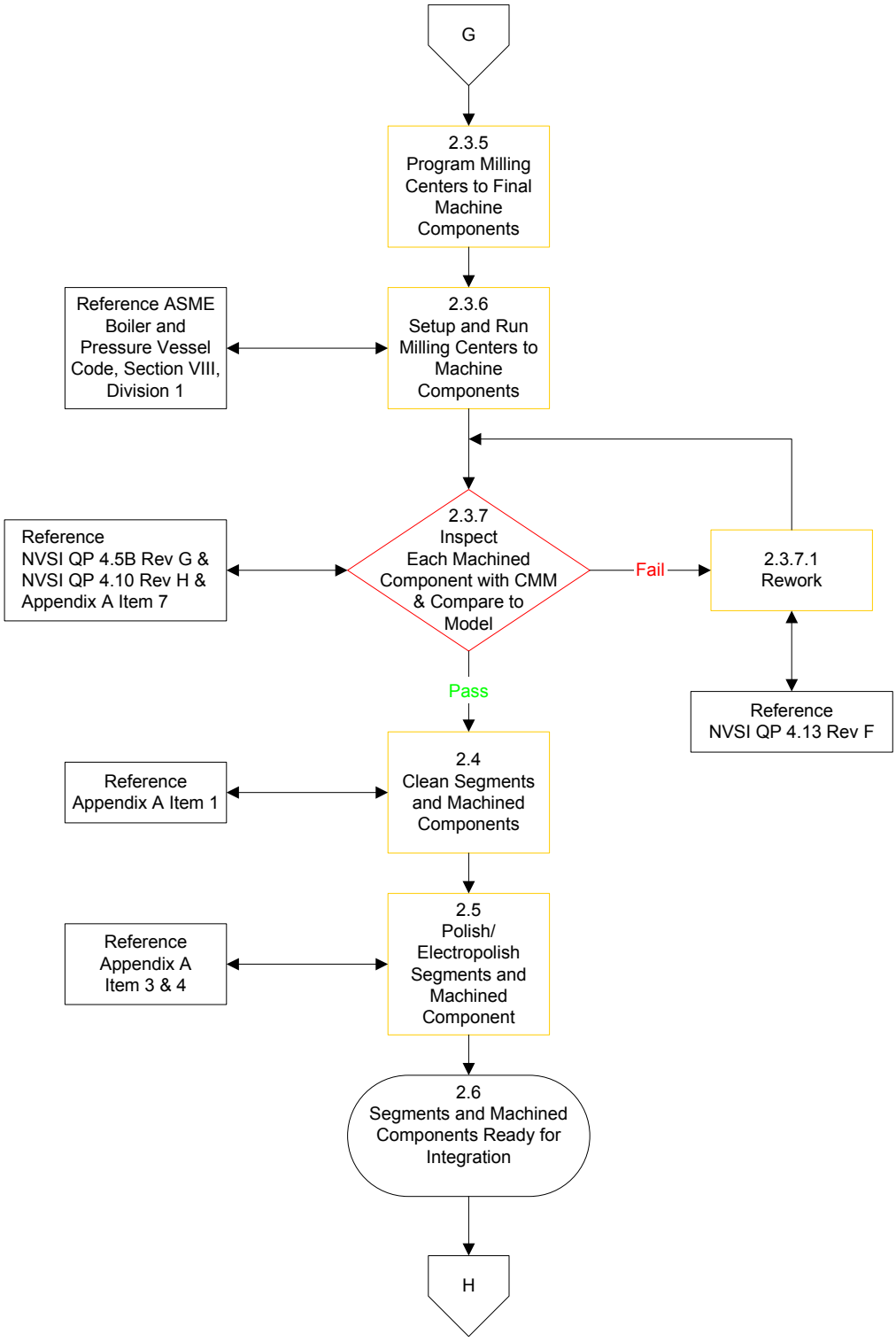

1.0
Segment
Fabrication
D
1.8.22
Locate Reference
Points on Die Rib
Assembly
1.8.23
Add Locking
Device for Press
Break
Step 1.9
Reference
Appendix A Item 1
1.8.24
Clean Die Rib
Assembly
Surfaces
1.9
Form Segment
1.9.1
Program Water Jet
to Pre-cut
Segment Material
(to be Oversized)
Reference ASME
Boiler and
Pressure Vessel
Code, Section VIII,
Division 1
1.9.2
Setup and Run
Water Jet to Pre-
cut Segment
Material
1.9.3
Form Segment
1.9.4
Stress Relieve
Segment
1.9.5
Using Reference Points
on Die Rib Assembly
Locate and Place
Reference Points on
Segment (CMM)
E

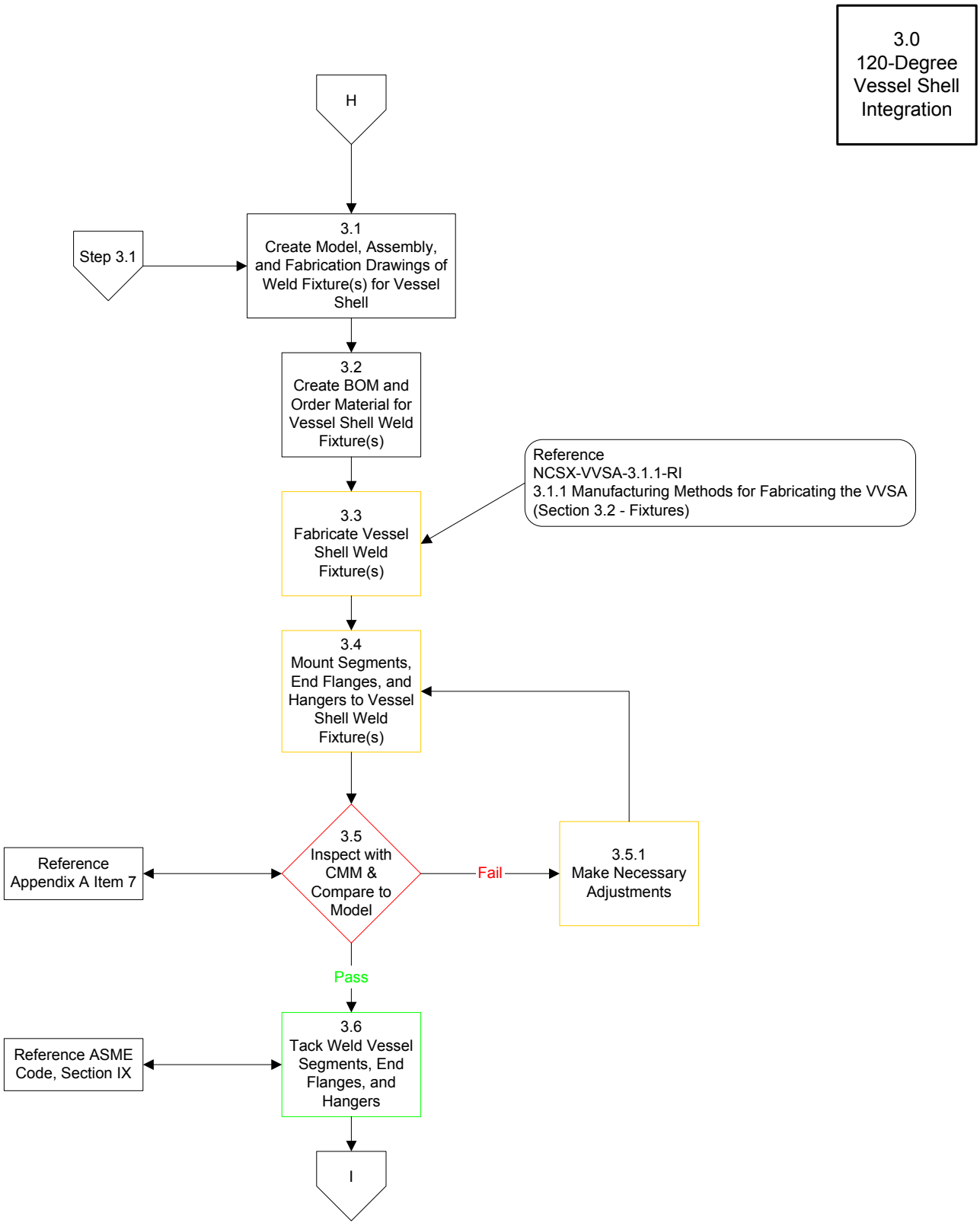
1.0
Segment
Fabrication



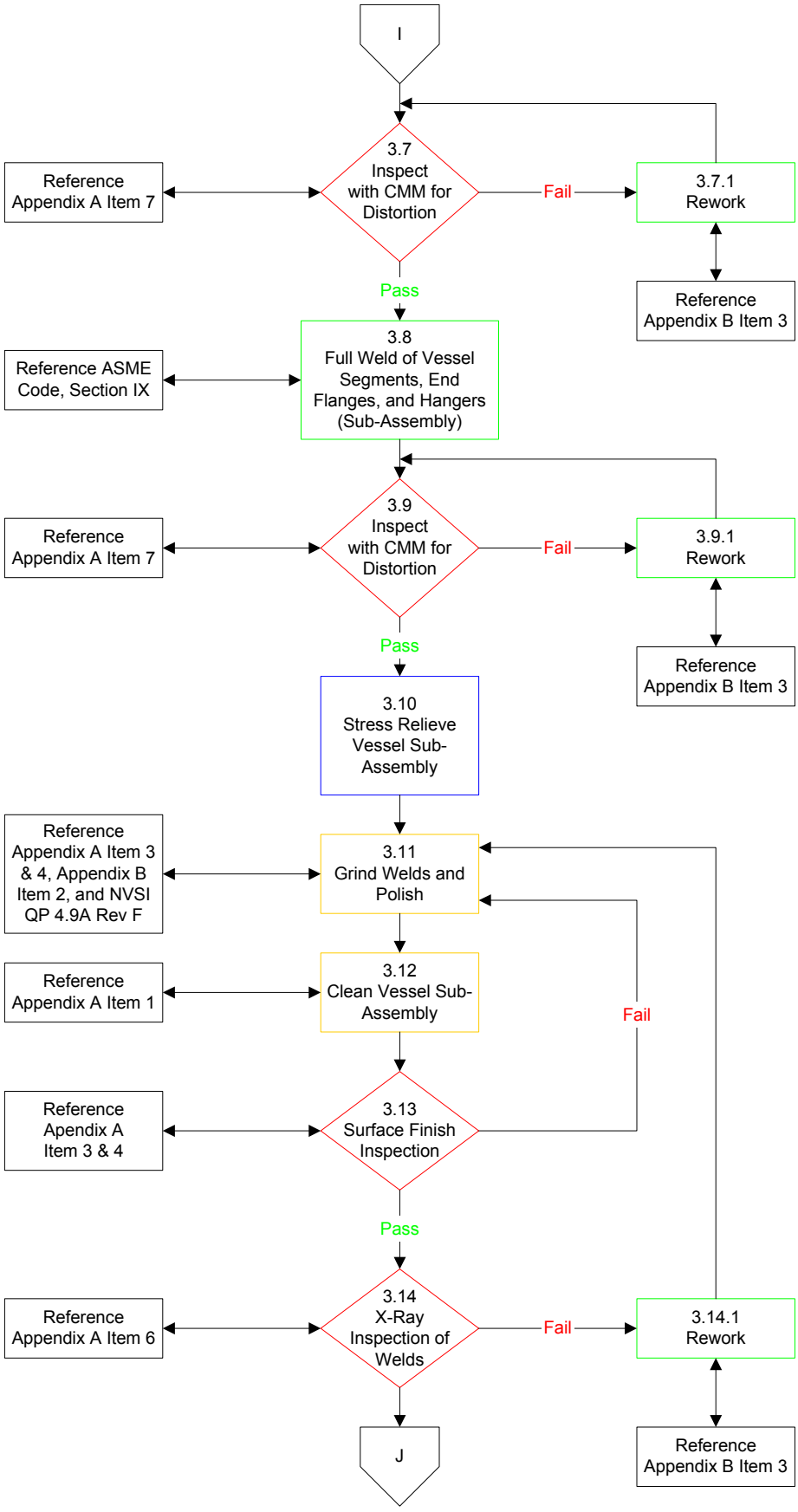

2.0
Machined
Components
Fabrication
F
2.1
Create BOM for
Machined
Components
Machined Components Include:
- End Flanges
- Custom Port Flanges
- Flange Covers
- Hangers
2.2
Order Material for
Machined
Components
Fail
2.3
Fabricate
Machined
Components
2.3.1
Receive/
Inspect
Material
Reference
Appendix B Item 1
Pass
2.3.2
Program Water Jet
to Rough Cut
Machined
Components
Reference ASME
Boiler and
Pressure Vessel
Code, Section VIII,
Division 1
2.3.3
Rough Cut
Machined
Components (to
be Cut Oversized)
Fail
Reference
NVSI QP 4.5B Rev G &
NVSI QP 4.10 Rev H
2.3.4
First Piece Visual
Inspection of Each
Machined
Component
G

2.0
Machined
Components
Fabrication

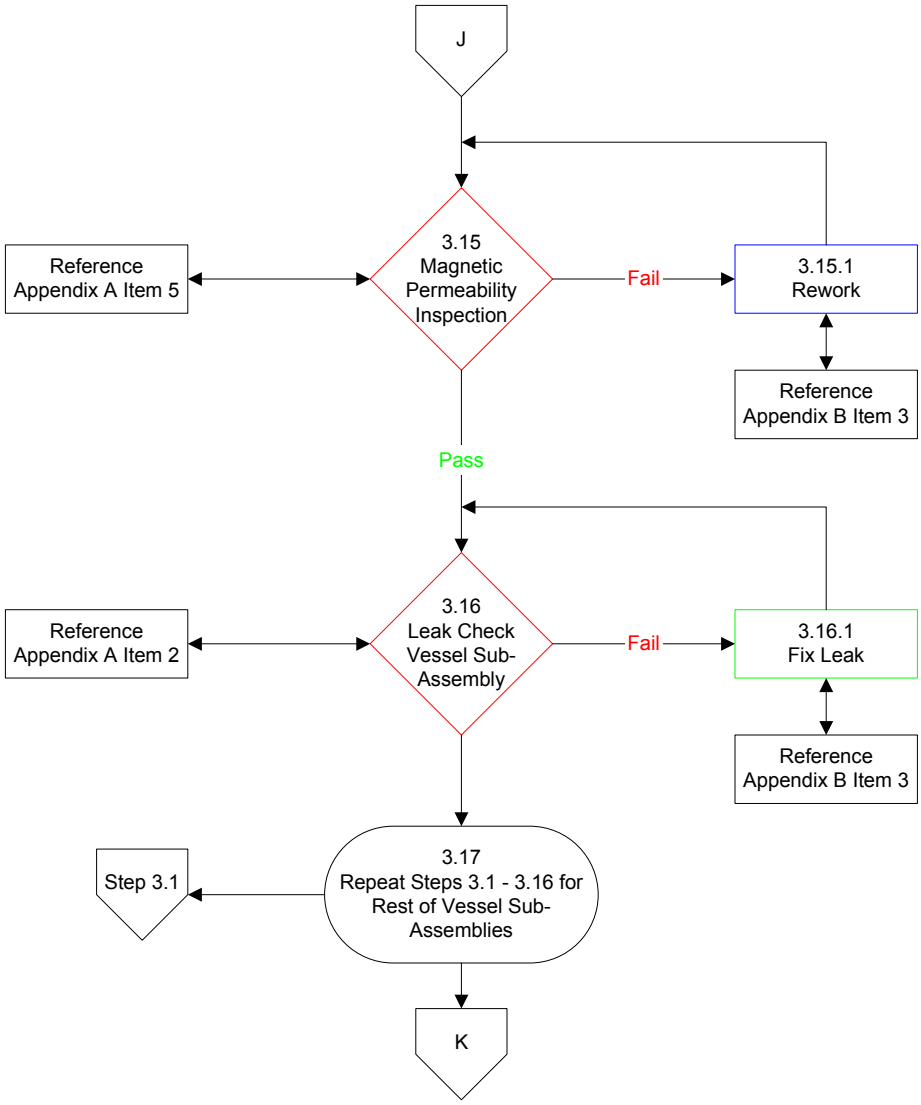


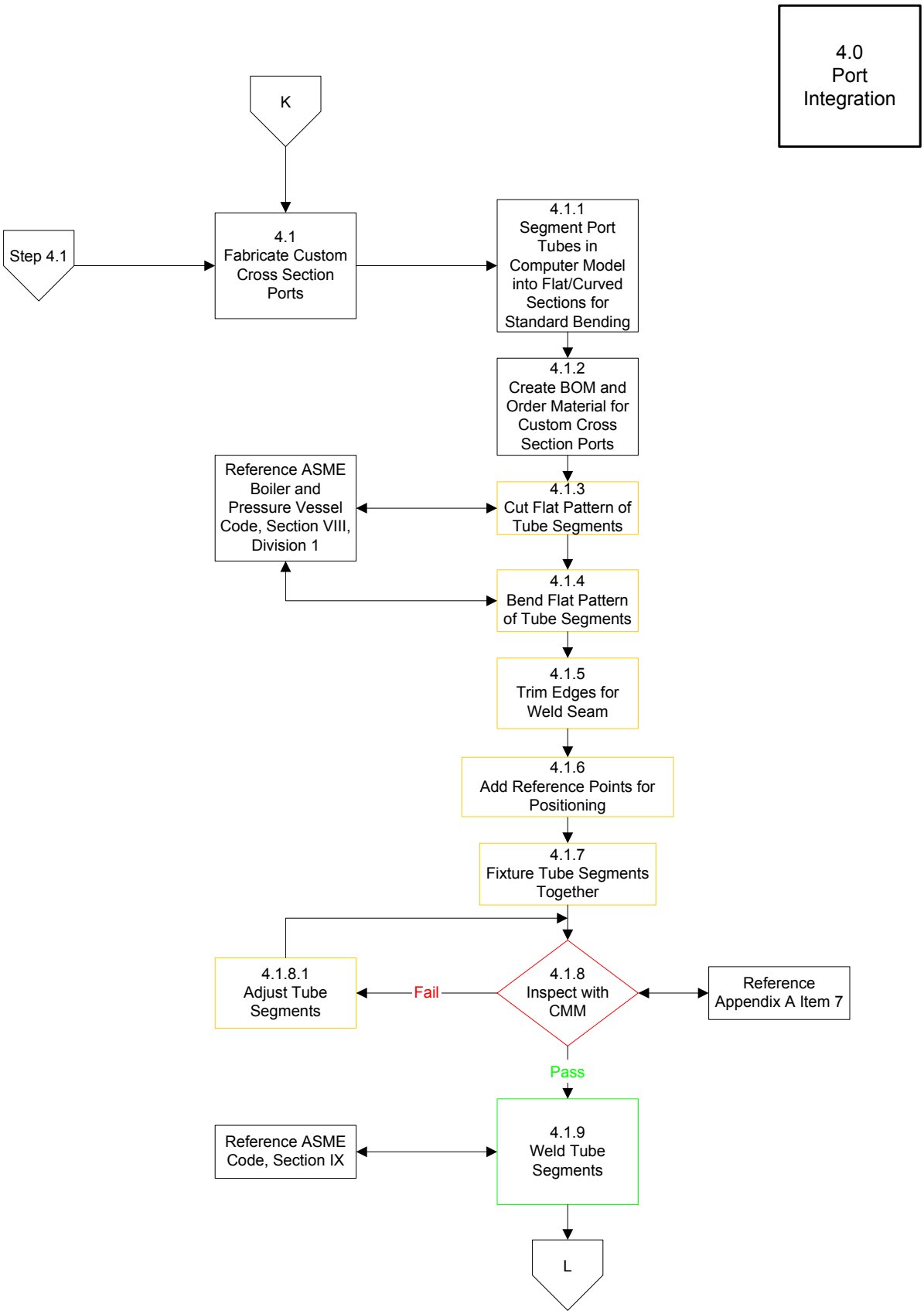

3.0
120-Degree
Vessel Shell
Integration
H
Step 3.1
3.1
Create Model, Assembly, and Fabrication Drawings of Weld Fixture(s) for Vessel Shell
3.2
Create BOM and Order Material for Vessel Shell Weld Fixture(s)
Reference
NCSX-VVSA-3.1.1-RI
3.1.1 Manufacturing Methods for Fabricating the VVSA
(Section 3.2 - Fixtures)
3.3
Fabricate Vessel Shell Weld Fixture(s)
3.4
Mount Segments, End Flanges, and Hangers to Vessel Shell Weld Fixture(s)
Reference
Appendix A Item 7
3.5
Inspect with CMM & Compare to Model
Fail
3.5.1
Make Necessary Adjustments
Pass
Reference ASME
Code, Section IX
3.6
Tack Weld Vessel Segments, End Flanges, and Hangers
I

3.0
120-Degree
Vessel Shell
Integration

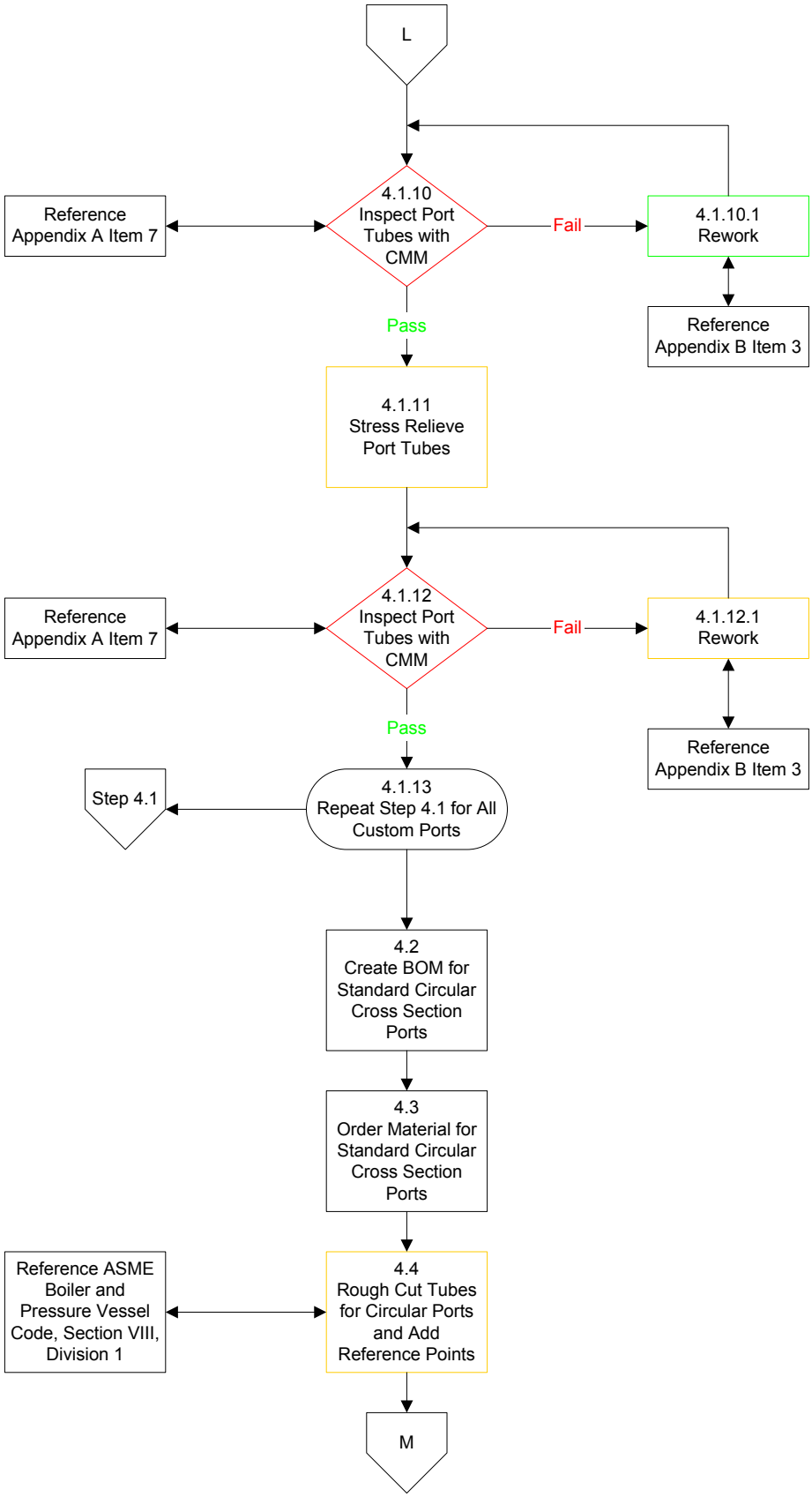


3.0
120-Degree
Vessel Shell
Integration

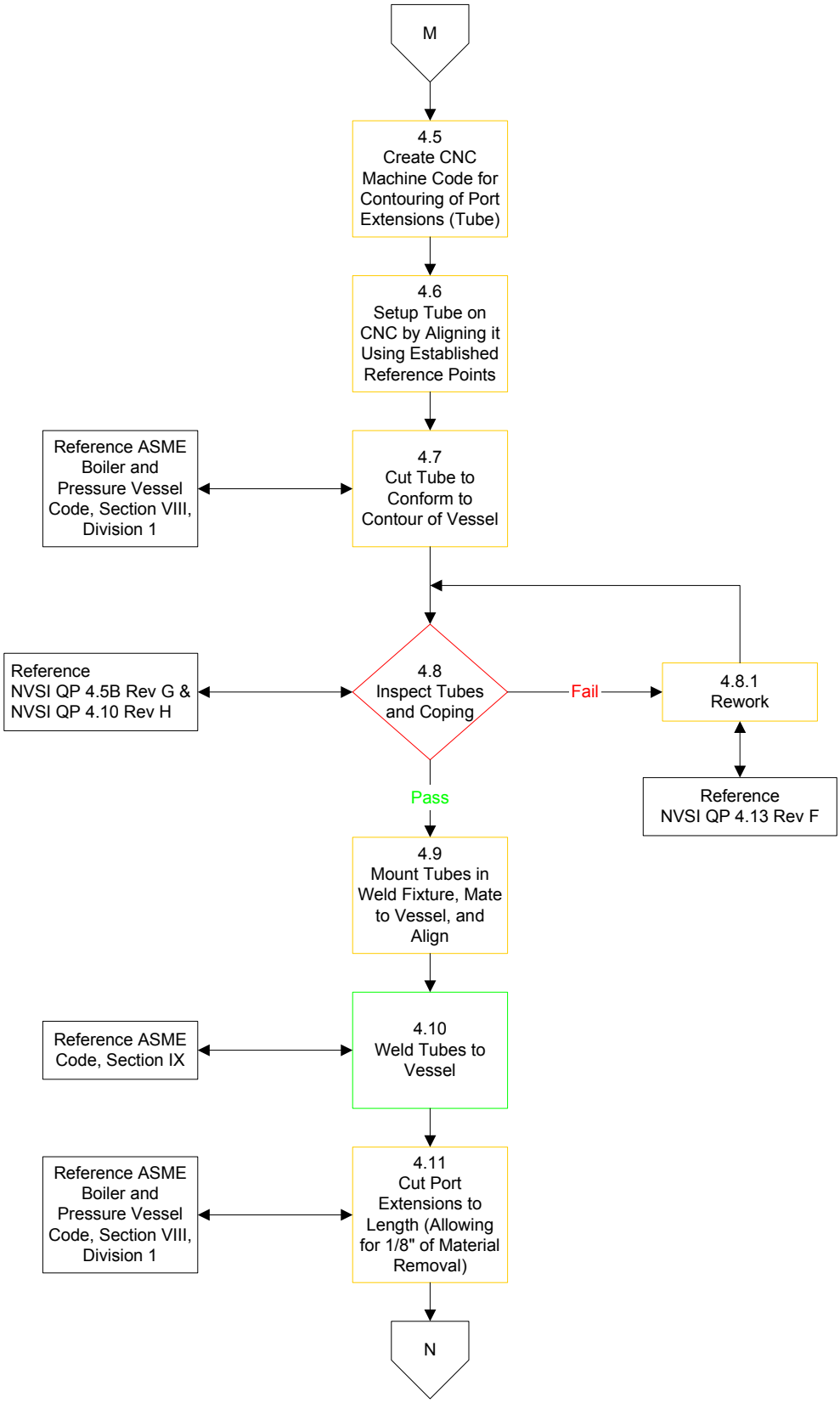



4.0
Port
Integration
K
Step 4.1
4.1
Fabricate Custom
Cross Section
Ports
4.1.1
Segment Port
Tubes in
Computer Model
into Flat/Curved
Sections for
Standard Bending
4.1.2
Create BOM and
Order Material for
Custom Cross
Section Ports
Reference ASME
Boiler and
Pressure Vessel
Code, Section VIII,
Division 1
4.1.3
Cut Flat Pattern of
Tube Segments
4.1.4
Bend Flat Pattern
of Tube Segments
4.1.5
Trim Edges for
Weld Seam
4.1.6
Add Reference Points for
Positioning
4.1.7
Fixture Tube Segments
Together
4.1.8.1
Adjust Tube
Segments
Fail
4.1.8
Inspect with
CMM
Reference
Appendix A Item 7
Pass
Reference ASME
Code, Section IX
4.1.9
Weld Tube
Segments
L

4.0
Port
Integration



4.0
Port
Integration



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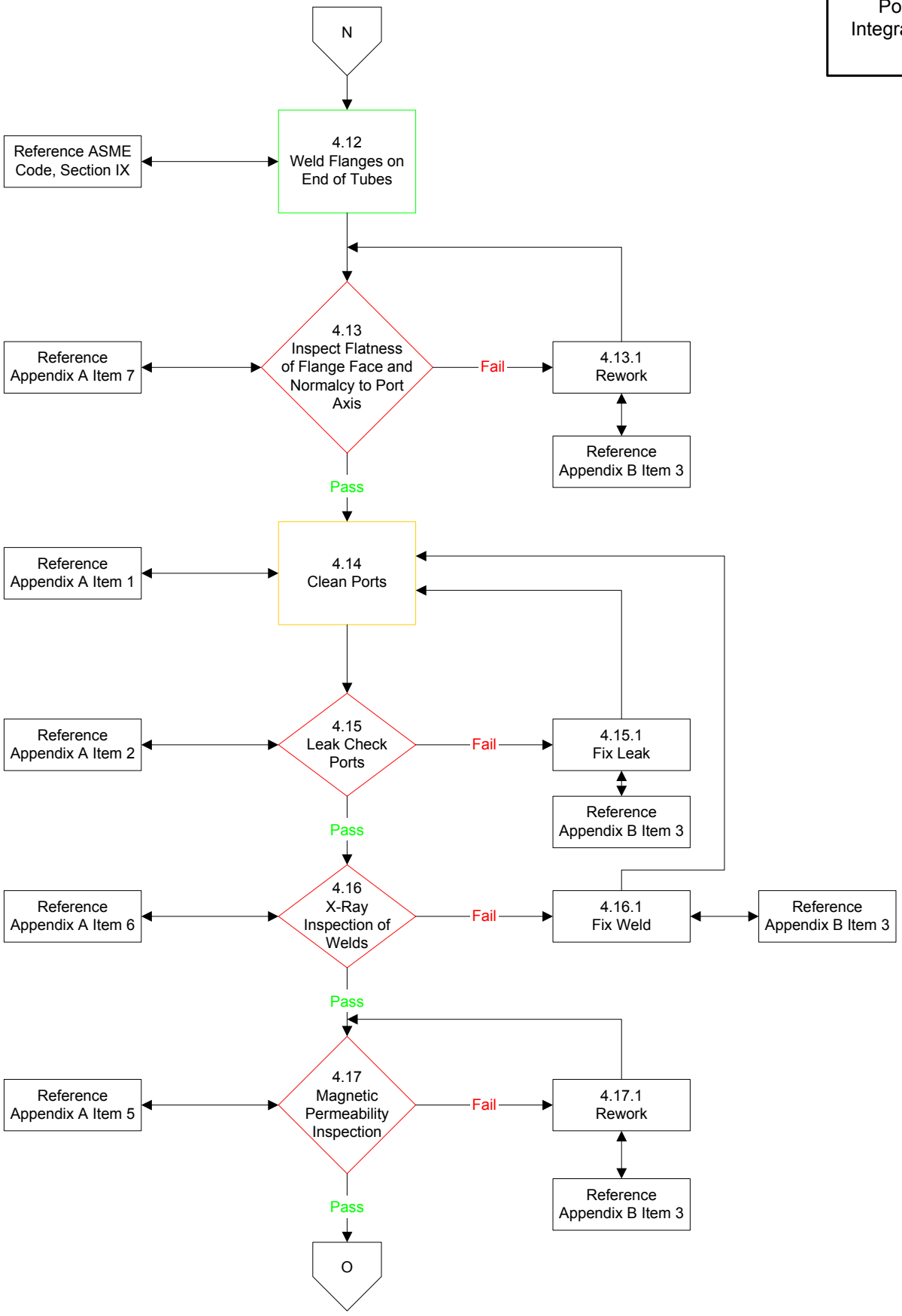
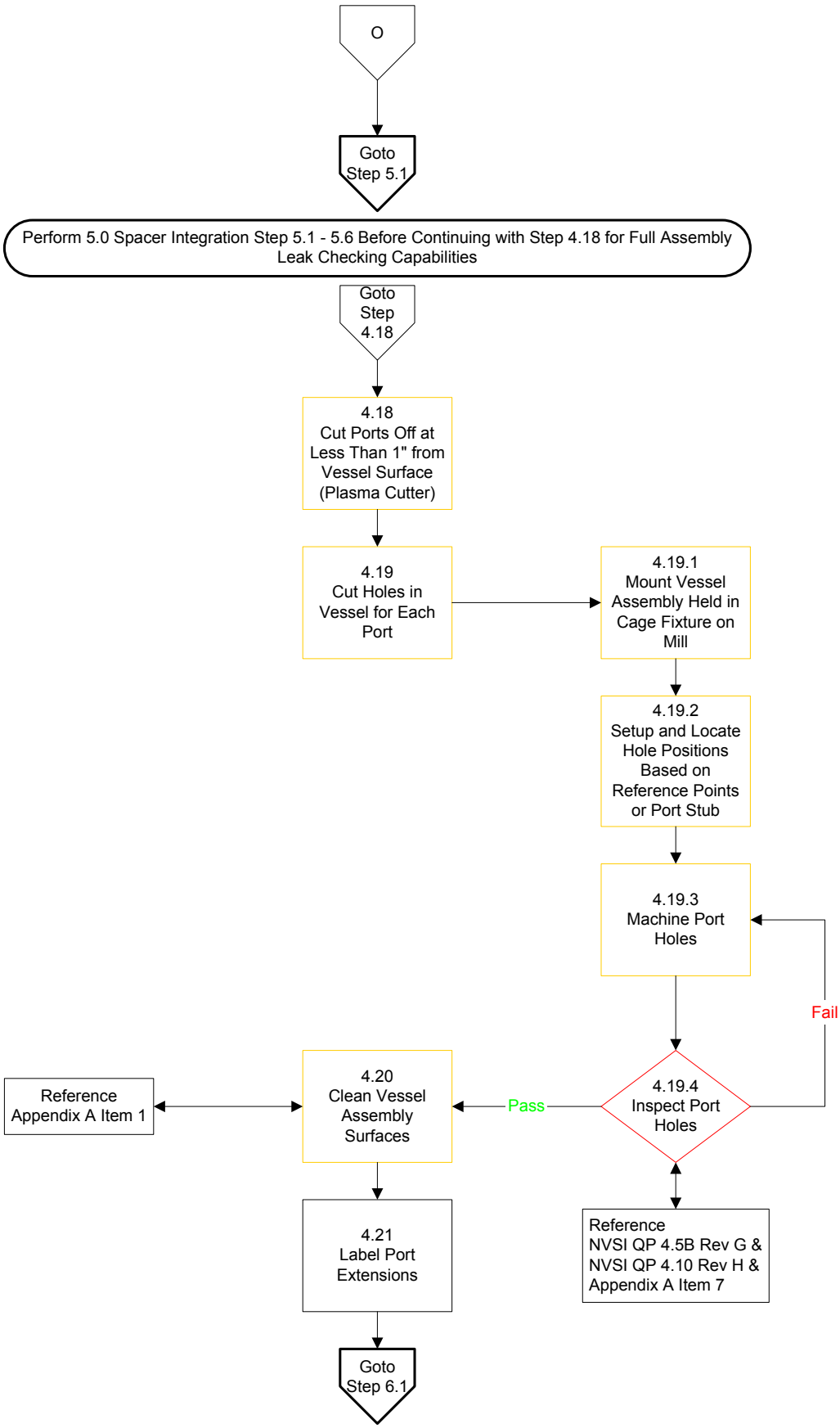
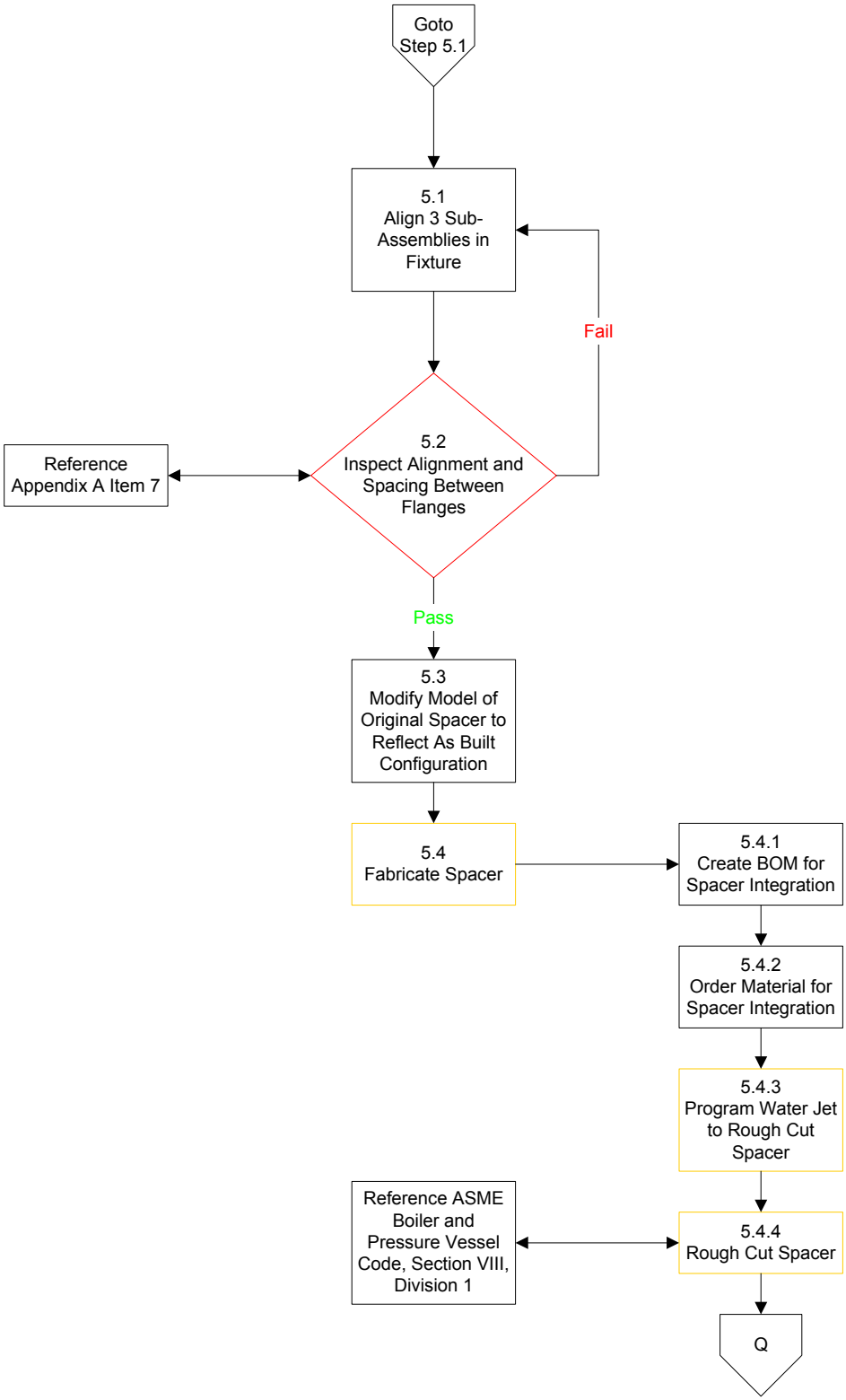
Port
Integration

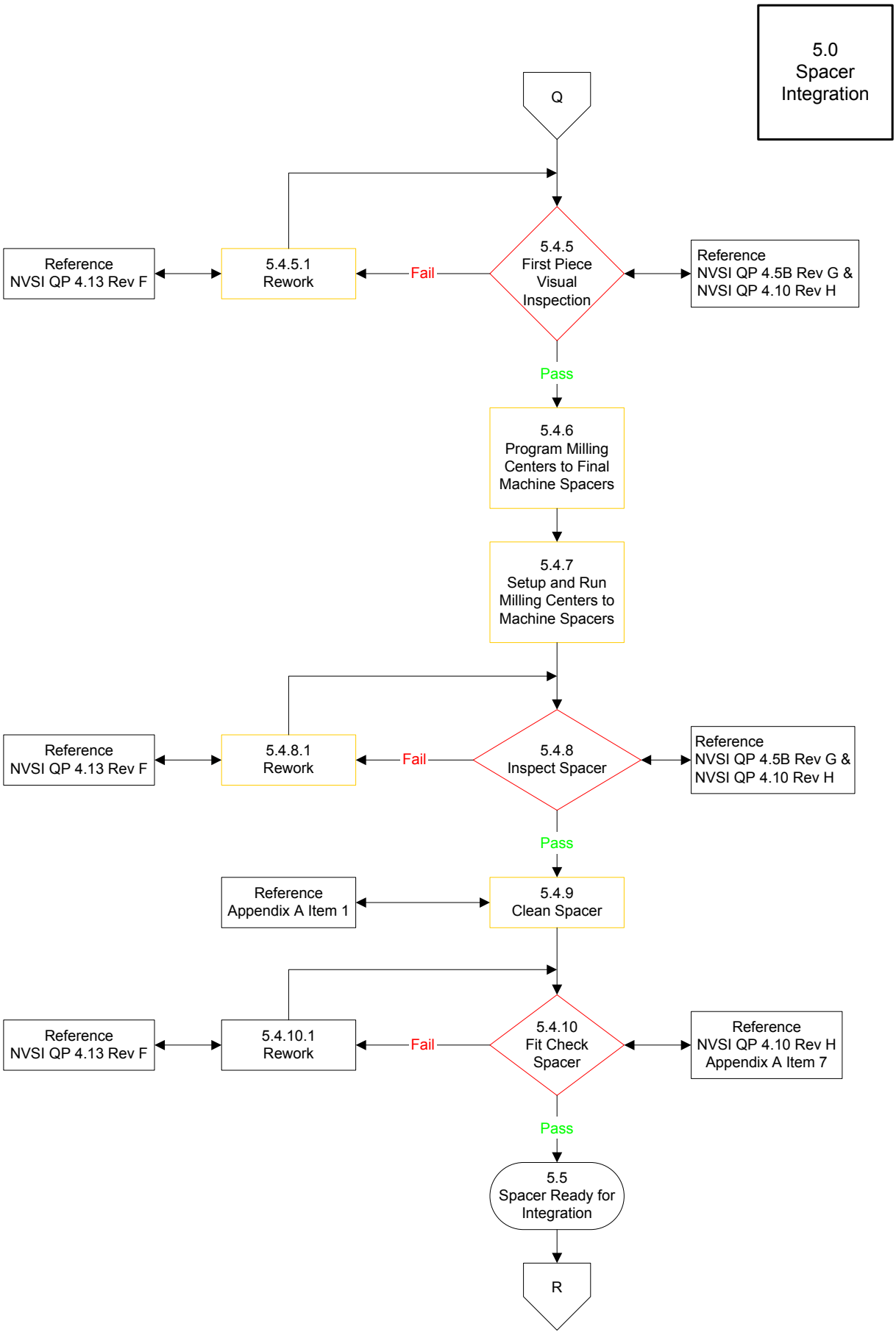


4.0
Port
Integration

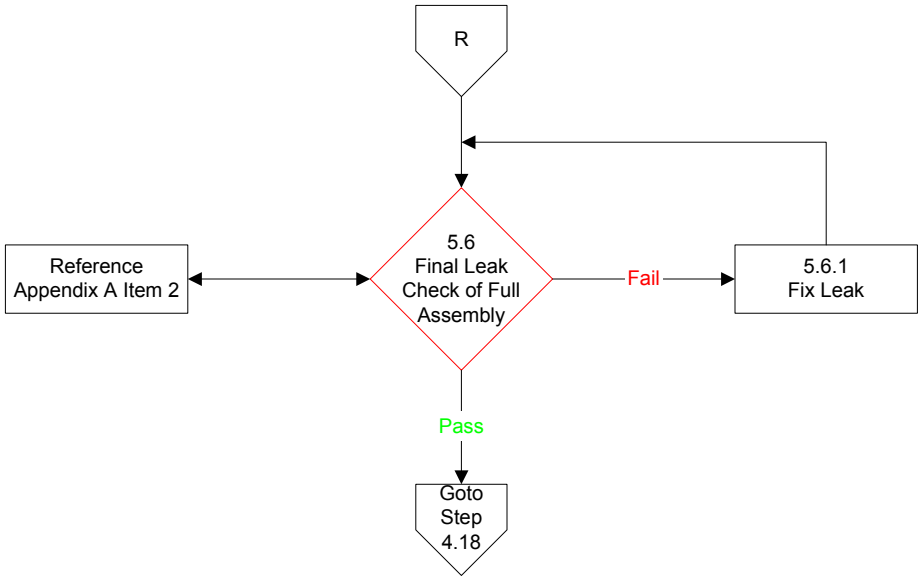


5.0
Spacer
Integration

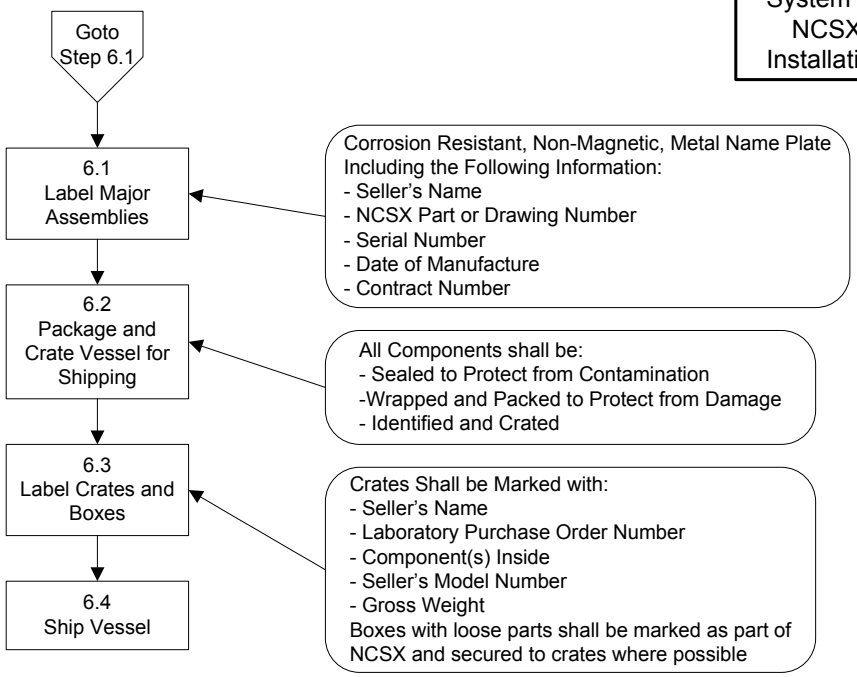



5.0
Spacer
Integration
Q
5.4.5
First Piece
Visual
Inspection
Fail
5.4.5.1
Rework
Reference
NVSI QP 4.13 Rev F
Reference
NVSI QP 4.5B Rev G &
NVSI QP 4.10 Rev H
Pass
5.4.6
Program Milling
Centers to Final
Machine Spacers
5.4.7
Setup and Run
Milling Centers to
Machine Spacers
5.4.8
Inspect Spacer
Fail
5.4.8.1
Rework
Reference
NVSI QP 4.13 Rev F
Reference
NVSI QP 4.5B Rev G &
NVSI QP 4.10 Rev H
Pass
5.4.9
Clean Spacer
Reference
Appendix A Item 1
5.4.10
Fit Check
Spacer
Fail
5.4.10.1
Rework
Reference
NVSI QP 4.13 Rev F
Reference
NVSI QP 4.10 Rev H
Appendix A Item 7
Pass
5.5
Spacer Ready for
Integration
R

5.0
Spacer
Integration



6.0
Breakdown
System for
NCSX
Installation



Appendix A

1. Cleaning Procedure
   - Use High Pressure Steam Cleaner with biodegradable UHV compatible detergent to remove oils, grease, and die lubricant residues resulting from handling.
   - Wipe down surfaces with solvent (e.g. Ethanol).
   - Blow dry surfaces with oil free instrument air.
   - Use lint free wipes.

2. Leak Check Procedure
   - Testing shall be done in accordance with NVSI Qp4.10 Rev H/ASTM E498.
   - Ports and assemblies shall be cleaned in accordance with Item 1 Cleaning Procedure above.
   - VVSA shall be leak checked a minimum of times after cycling between room temperature and 200 C.
   - Ports should be evacuated using a mechanical pump and turbo molecular pump to a base pressure equal to or less than 1.0 E-7 Torr and have a total helium leak rate equal to or less than 1.0E-9 sccm/s (7.6E-10 Torr-L/s).
   - Sub-assemblies and full assembly should be evacuated using a mechanical pump and turbo molecular pump to a base pressure equal to or less than 1.0 E-7 Torr and have a total helium leak rate equal to or less than 1.0E-9 sccm/s (7.6E-10 Torr-L/s).
   - Leaks shall be documented on nonconformance reports and repaired.

3. Interior Surface Finish Procedure
   - VVSA interior surfaces, including ports, shall be mechanically ground and electropolished to a 32 micro inch finish or better per ASME B46.1.
   - All finishing tools used shall be nonferrous ceramics or nonmagnetic stainless steel and must be new or previously used on Inconel or austentic steel only.

4. External Surface Finish Procedure
   - Mill Finish Acceptable
   - Gouges greater than 0.06" shall be weld repaired and ground smooth.

5. Magnetic Permeability Requirements
   - Magnetic permeability measurements shall meet requirements of ASTM A800 Supplementary Requirement S1.
   - Measurements shall be relative permeability rather than ferrite content.
   - All features and surfaces shall be measured with a Severn Permeability Indicator1.
   - The VVSA shall be measured over a 6" X 6" grid.
   - All welds shall be measured every ½", inside and outside wherever possible.
   - Overall relative magnetic permeability of all components fabricated of nickel chromium alloy shall not exceed 1.01.
   - Overall relative magnetic permeability of all components fabricated of 316 LN stainless steel shall not exceed 1.02.
   - Overall relative magnetic permeability in all welds (and heat affected zones) joining 316 LN stainless steel to nickel chromium alloy shall not exceed 1.2.

Appendix A

6. Weld Inspection Procedure
   - Weld Inspections shall meet the requirements of NVSI ASME Quality Manual 2nd Edition Revision A Section 11 and 12/NVSI QP 4.10 Rev H

7. CMM Dimension and Tolerance Verification
   - Reference NVSI QP 4.5B Rev B and NVSI QP 4.10 Rev H
   - VVSA measurements shall be done pre and post port cut off.
   - All features and surfaces shall be checked on a grid with less than or equal to 1" centers.
   - All measurements shall be compared to applicable models and drawings.

Appendix B

1. Materials
   - All sheet, strip, and plate metal shall be annealed Alloy UNS N06625 and meet ASTM B 443 Requirements.
   - All piping and tubing shall be seamless or welded alloy UNS N06625 and meet ASTM B 444 or ASTM B 705 requirements.
   - All bar and structural shapes shall be annealed alloy UNS N06625 and meet ASTM B 446.
   - All conflat flanges shall be fabricated of austentic stainless steel and meet ASTM A 240 requirements.
   - Weld filler metal shall meet the applicable requirements of ASME SFA Specifications or AWS A Series Specifications. ASME SFA or AWS A 5.14 requirements and ERNiCr-3 or ERNiCrMo-3 filler metal shall be used when welding stainless steel conflat flanges to UNS N06625 ports.
   - Conflat flange bolts shall be, 12-point silver plated, ASTM A 193 - Grade B8.
   - Standard copper seals shall be used where metal seals are necessary.
   - Viton A O-Rings shall be used where o-ring seals are necessary.

2. Material and Tooling Selection/Control
   - Material and Tooling Selection/Control shall meet the requirements of NVSI ASME Quality Manual 2nd Edition Revision A Section 8/NVSI QP 4.5B Rev G

3. Weld Repair Procedure
   - Weld Repairs shall meet the requirements of NVSI ASME Quality Manual 2nd Edition Revision A Section 11, 12, and 14/NVSI QP 4.10 Rev H & NVSI QP 4.13 Rev F