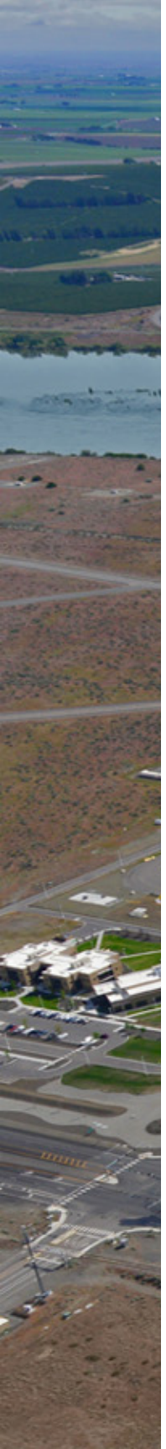

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Inservice Inspection Considerations for AMT Components

Joel Harrison

PNNL-SA-158418

U.S. DEPARTMENT OF ENERGY BATTELLE

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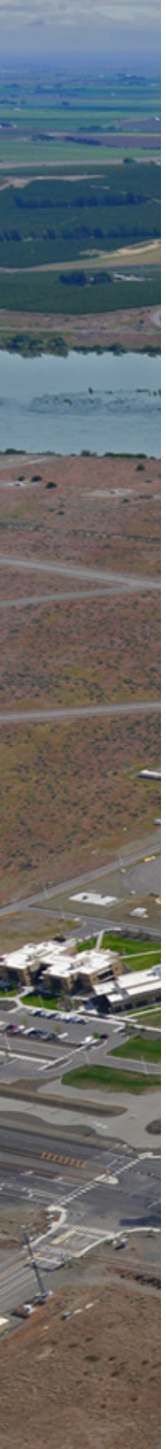

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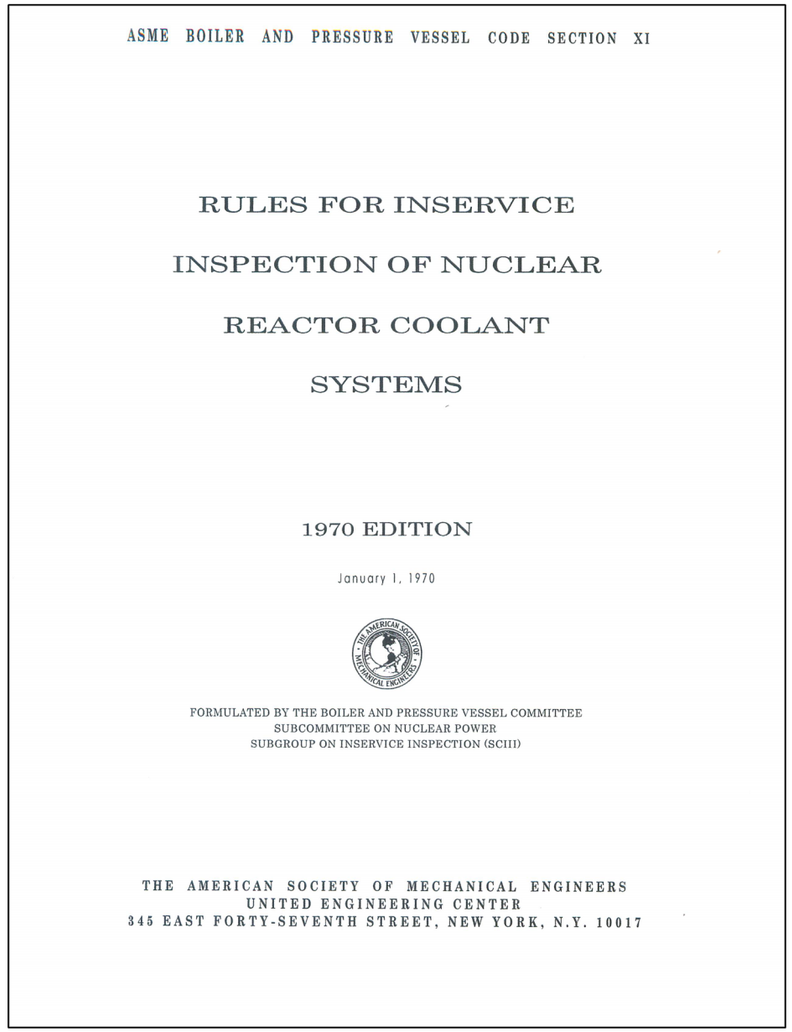
Advanced Manufacturing Techniques

- **AMT has gained significant attention and success in several industries**
  - Aerospace, automotive, medical, consumer products, and energy
- **ASME Code and the nuclear power industry is yet to fully embrace AMT**
  - The nuclear industry could benefit from precision replacement components that are difficult to obtain due to a reduction or loss of supply chain capabilities
  - AMT components must meet quality and regulatory requirements
  - The NDE methods employed during ISI of the existing nuclear fleet have evolved over more than 40 years into an established practice with strong technical and regulator backing
  - There are several papers and reports on NDE of AMT components but none related to ISI

ASME Section XI

- **Draft published in 1968**
- **First Edition published on January 1, 1970**
  - Entire document was 42 pages with only 24 devoted to ISI requirements
- **Compared to 2019 Edition – 676 pages**
- **Rules for Inservice Inspection of Nuclear Power Plant Components**
  - Does not cover component fabrication NDE or plant construction/Repair Replacement NDE
  - These issues are addressed in ASME Section III



ASME BOILER AND PRESSURE VESSEL CODE SECTION XI

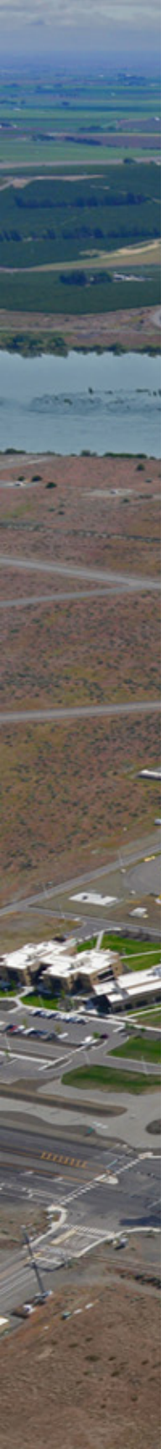
RULES FOR INSERVICE
INSPECTION OF NUCLEAR
REACTOR COOLANT
SYSTEMS

1970 EDITION

January 1, 1970

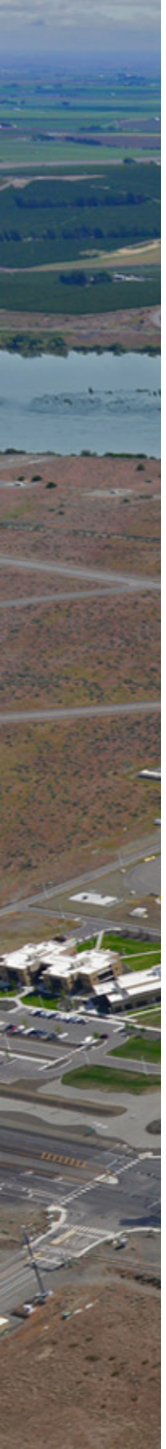
FORMULATED BY THE BOILER AND PRESSURE VESSEL COMMITTEE
SUBCOMMITTEE ON NUCLEAR POWER
SUBGROUP ON INSERVICE INSPECTION (SCIII)

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
UNITED ENGINEERING CENTER
345 EAST FORTY-SEVENTH STREET, NEW YORK, N.Y. 10017



ASME Section XI

- **Currently no discussion regarding ISI of AMT fabricated components within Section XI NDE Committees**
- **Only one Code Case, N-834, has been adopted in ASME Section III, Division 1**
  - PM-HIP of 316L Stainless Steel
  - EPRI Report 1025491, May 2012
- **ASME's Board on Pressure Technology Codes and Standards (BPTCS) and Board on Nuclear Codes and Standards (BNCS)**
  - Convened Special Committee on Use of Additive Manufacturing for Pressure Retaining Equipment
  - Scheduled to meet quarterly during ASME Code Week



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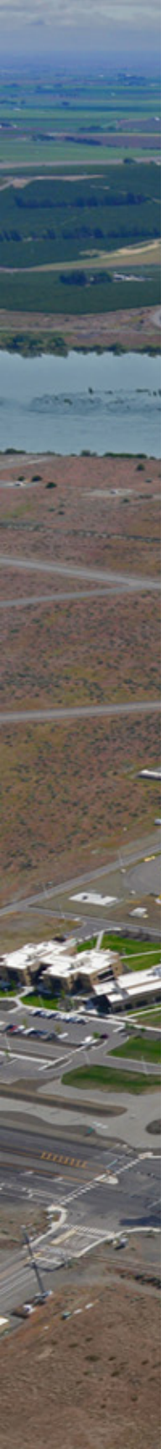
Thoughts Regarding ISI of AMT Components

- **Are AMT fabricated components comparable to conventionally fabricated methods?**
  - Without investigation, how can we know for sure?
  - Such information will help define inspection volumes and intervals and provide the basis for the development of aging management programs
- **How will proprietary AMT processes and manufacturing methods be standardized?**
- **Can it be anticipated that considerations for most ISI of AMT components would overlap with those of conventional components?**



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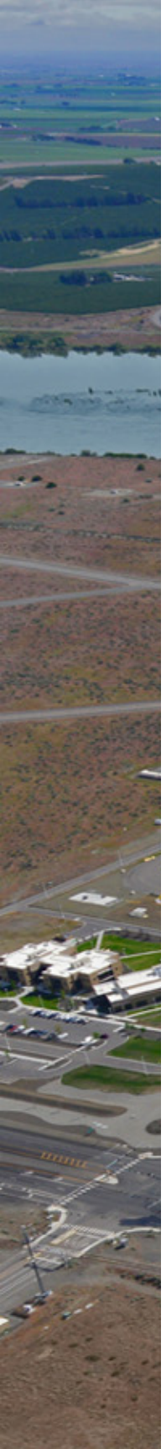
Thoughts Regarding ISI of AMT Components

- **An AMT component may contain no welds, so the inspection volume cannot be defined in terms of weld regions.**
  - What is the relevant inspection volume?
  - How is a piping component welded to a valve body or piping elbow fabricated by an AMT process defined?
- **Can critical defects, once defined, be detected with current NDE technology?**
- **What will be the NDE resolution requirements?**
  - Can NDE techniques be validated without destructive testing?
- **Will the grain structure of the AMT components interfere with UT detection?**



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Section XI IWA-220 Applicable NDE Methods

- **Visual**
  - VT, VT-1, VT-2, VT-3
- **Surface**
  - Liquid Penetrant, Magnetic Particle, Eddy Current
- **Volumetric**
  - Radiography, Ultrasound, Eddy Current, Acoustic Emission

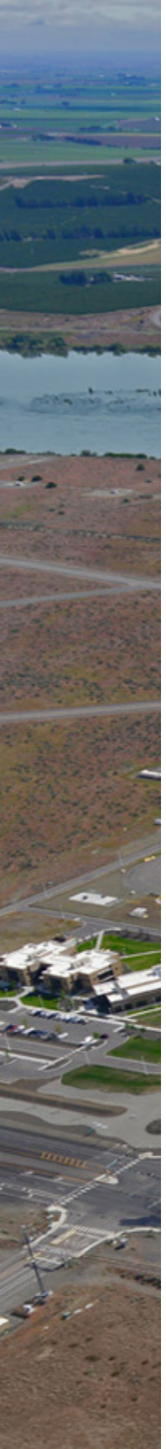
Section XI Examination Requirements - Visual

- **Class 1 components identified in Section IWB-2500**

Table IWB-2500-1 (B-L-2, B-M-2)
Examination Categories B-L-2, Pump Casings; B-M-2, Valve Bodies

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals	
	Pumps				Internal surface [Note (1)]	Same as for first interval	See [Note (2)]
B12.20	Pump casing (B-L-2)	Internal surfaces	Visual, VT-3	IWB-3519			
	Valves				Internal surface [Note (3)]	Same as for first interval	See [Note (2)]
B12.50	Valve body, exceeding NPS 4 (DN 100) (B-M-2)	Internal surfaces	Visual, VT-3	IWB-3519			

NOTES:
(1) Examinations are limited to at least one pump in each group of pumps performing similar functions in the system, e.g., recirculating coolant pumps.
(2) Examination is required only when a pump or valve is disassembled for maintenance, or repair. Examination of the internal pressure boundary shall include the internal pressure-retaining surfaces made accessible for examination by disassembly. If a partial examination is performed and a subsequent disassembly of that pump or valve allows a more extensive examination, an examination shall be performed during the subsequent disassembly. A complete examination is required only once during the interval.
(3) Examinations are limited to at least one valve within each group of valves that are of the same size, constructural design (such as globe, gate, or check valves), and manufacturing method, and that perform similar functions in the system (such as containment isolation and system overpressure protection).



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Visual Examination

- **Early AMT fabrication attention in the nuclear power industry has been on pump and valve housings.**
- **Visual examinations should be relatively straight forward provided:**
  - Anticipated flaw types have been determined
  - Critical flaw size & acceptance standards have been defined

Section XI Examination Requirements – Surface & Volumetric

- **Class 1 components identified in Section IWB-2500**

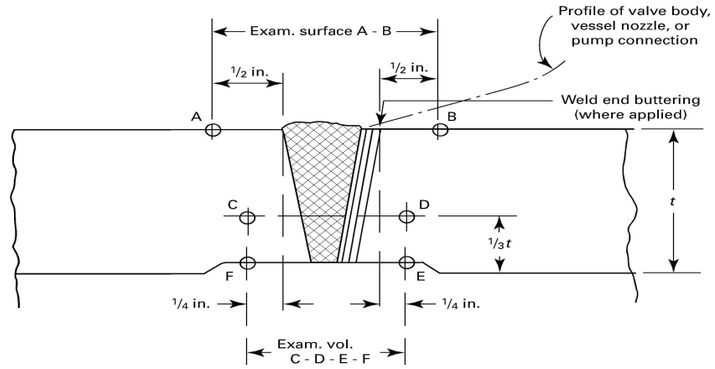
Table IWB-2500-1 (B-J)
Examination Category B-J, Pressure-Retaining Welds in Piping

Item No.	Parts Examined	Examination Requirements/ Figure No.	Examination Method	Acceptance Standard	Extent and Frequency of Examination		Deferral of Examination to End of Interval
					First Inspection Interval	Successive Inspection Intervals [Note (1)]	
B9.10	NPS 4 or larger (DN 100)	IWB-2500-8	Surface and volumetric	IWB-3514	Welds [Note (2)], [Note (3)], [Note (4)], [Note (5)], [Note (6)]	Same as for first interval	Not permissible
B9.11	Circumferential welds						
B9.20	Less than NPS 4 (DN 100)	IWB-2500-8		IWB-3514	Welds [Note (2)], [Note (3)], [Note (4)]	Same as for first interval	Not permissible
B9.21	Circumferential welds other than PWR high pressure safety injection systems		Surface				
B9.22	Circumferential welds of PWR high pressure safety injection systems		Volumetric		Welds [Note (3)], [Note (5)], [Note (6)], [Note (7)]		
B9.30	Branch pipe connection welds	IWB-2500-9, IWB-2500-10, and IWB-2500-11				Same as for first interval	Not permissible
B9.31	NPS 4 or larger (DN 100)		Surface and volumetric	IWB-3514	Welds [Note (2)], [Note (3)], [Note (4)], [Note (5)], [Note (6)]		
B9.32	Less than NPS 4 (DN 100)		Surface		Welds [Note (2)], [Note (3)], [Note (4)]		
B9.40	Socket welds	IWB-2500-8	Surface	IWB-3514	Welds [Note (2)], [Note (3)]	Same as for first interval	Not permissible

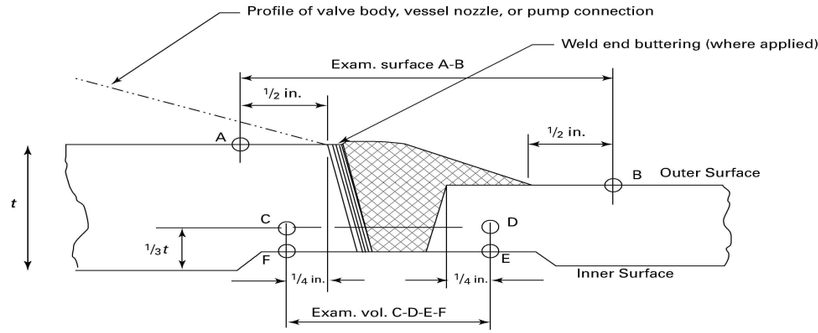
Section XI Examination Requirements – Surface & Volumetric

- Class 1 components identified in Section IWB-2500
- Examination volumed defined in reference to a weld

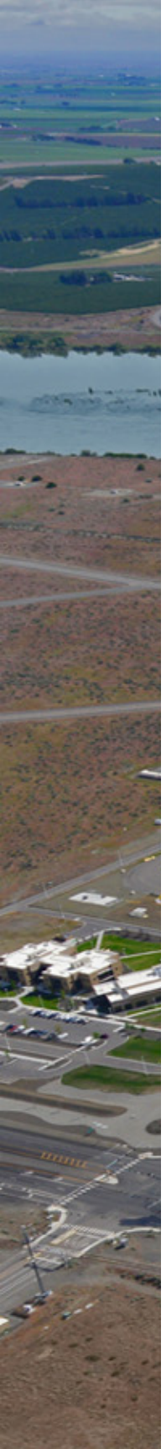
Figure IWB-2500-8
Similar and Dissimilar Metal Welds in Components, Nozzles, and Piping (Cont'd)



(c) NPS 4 (DN 100) or Larger



(d) NPS 4 (DN 100) or Larger



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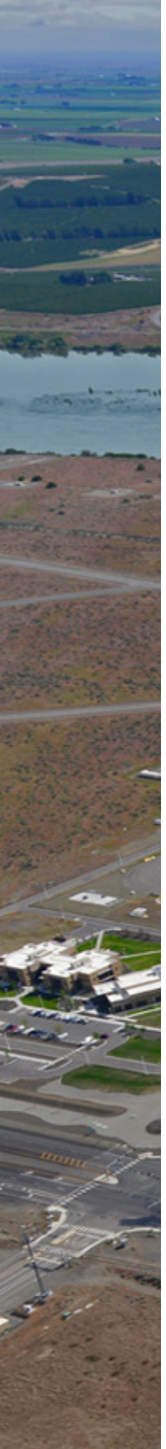
Surface & Volumetric Examination

- **Surface**
  - A important factor for surface examinations is surface finish. Will AMT components' surface finish be conducive to surface examinations?
- **Volumetric**
  - Volumetric examinations for inservice inspection are predominantly performed with ultrasound
  - Single sided exams – pipe to AMT valve or pump
    - ✓ Pump & Valve components are typically a casting
  - Pipe to AMT fabricated elbow in place of a CASS elbow
  - Appendix VIII Considerations



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Summary

- Advanced Manufacturing Technologies offer a potential benefit to the existing nuclear power fleet in fabricating replacement components.
- AMT could possibly reduce a utility's repair/replacement costs.
- If existing Codes & Standards are to be used for AMT components, research must be performed in order to ensure AMT equivalency with conventionally fabricated components.
- NDE methods and techniques applicable to AMT components must be validated through performance demonstration.
- ASME Code approval process is very long. If the industry is optimistic about utilizing AMT components a Section XI Committee should begin investigating possibilities.