CASS Inspections: The Path Forward

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Cast Austenitic Stainless Steel Inspections

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Welds with one or more Cast Austenitic Stainless Steel (CASS) component are currently not covered in ASME Code Section XI Appendix VIII

The NRC receives many relief requests each year as licensees cannot achieve full coverage for inspections of welds with one or more CASS components

Inspections of CASS components following Appendix III do not have as much rigor as those following Appendix VIII

ASME Code Section XI
Appendix VIII

1992 Edition

SUPPLEMENT 9 — QUALIFICATION REQUIREMENTS FOR CAST AUSTENITIC PIPING WELDS

(In the course of preparation)

2013 Edition

SUPPLEMENT 9 — QUALIFICATION REQUIREMENTS FOR CAST AUSTENITIC PIPING WELDS

(In the course of preparation)

Appendix III Supplement 1 Requirements

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Shear and longitudinal waves are both usable

Only one angle is required

A maximum transducer size is listed, but no minimum transducer size is described

Appendix III contains the sentence “Cast materials may preclude meaningful examinations because of geometry and attenuation variables.”

Cast Stainless Steel Grain Structure

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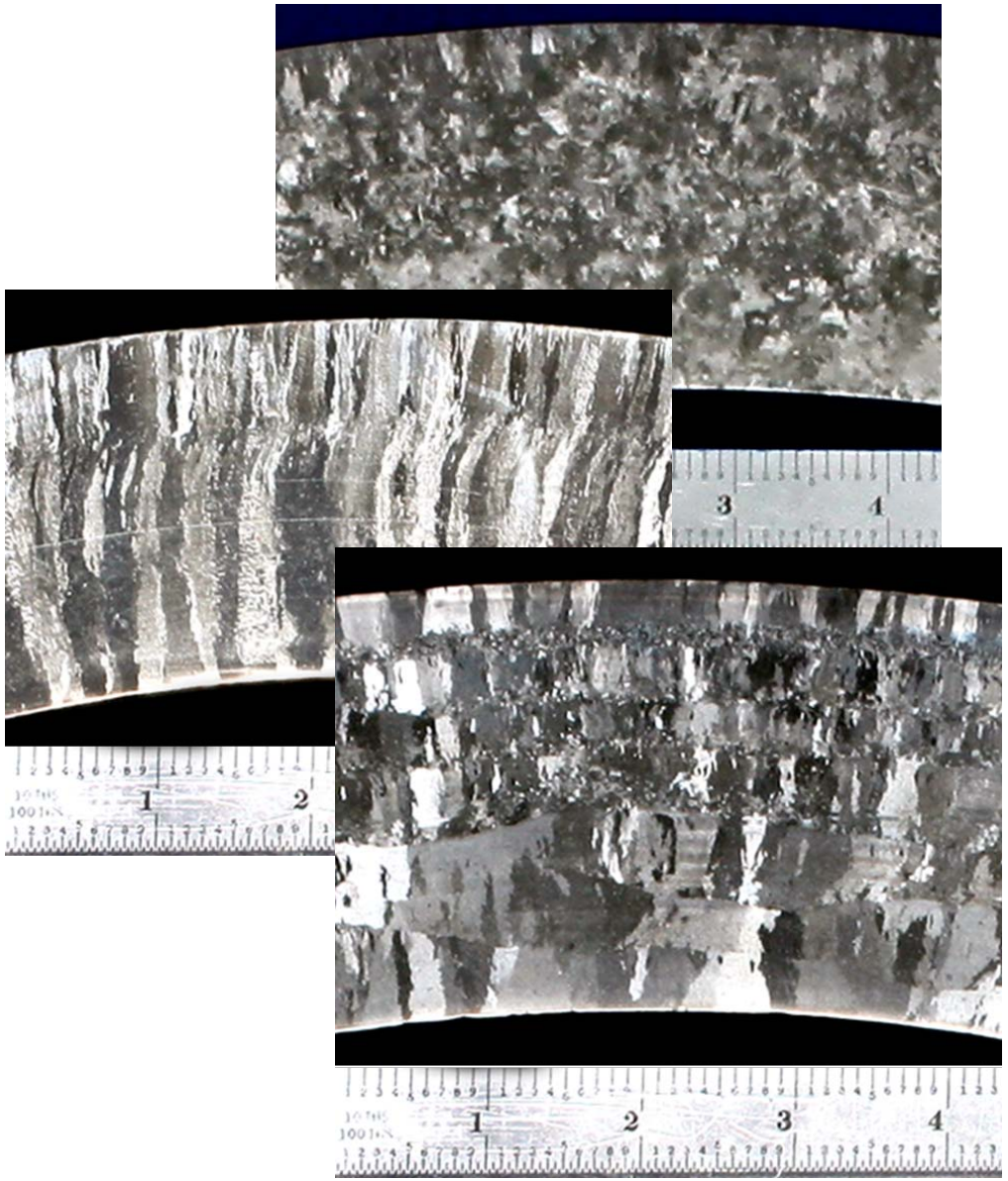
The grain structure of CASS redirects and attenuates ultrasonic beams

While CASS can have many grain morphologies, no distinction is made in ASME Code or Federal Regulations

Inspections that work for some CASS components may fail with others



CASS Inspectability

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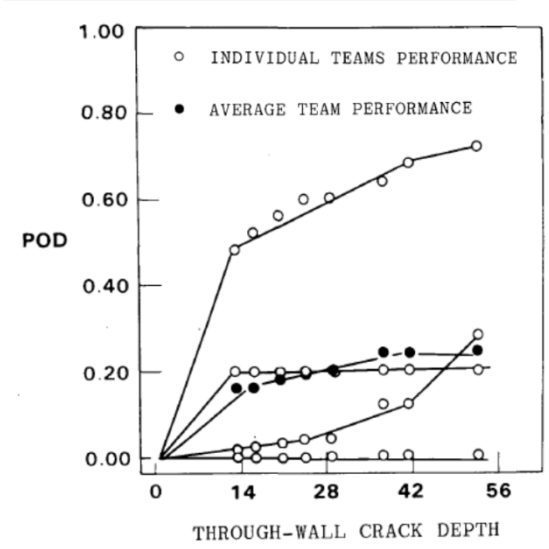
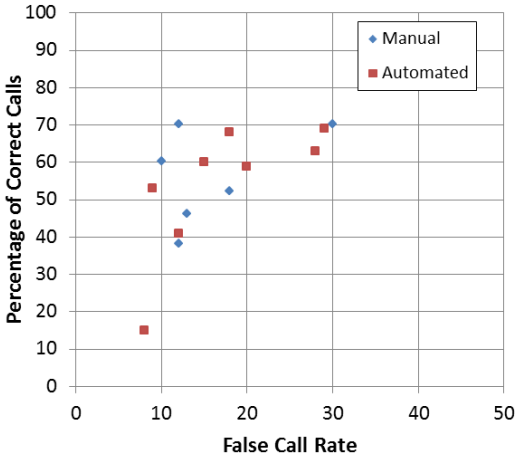
Older manual and automated conventional inspections have had a poor probability of detection for flaws in welds with one or more CASS components

The PODs achieved in the previous tests would have a challenging time passing an Appendix VIII-style qualification



Round Robin Test Results for CASS inspections using manual ultrasonic procedures in 1984



Results of a 1993 Round Robin Test of Heavy-Walled CASS Material

CASS and Cracking

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As CASS is very challenging to inspect and many CASS components have never been effectively inspected, it is not known if there is cracking in CASS components today

- No CASS components have leaked or failed to date

CASS components have a wide range of flaw tolerances depending on the delta ferrite levels and stress ratios

The possibility of a low flaw tolerance in some components that have never been effectively inspected is a concern to NRC staff

Recent NRC Sponsored Research

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The NRC has been funding research into the inspectability of CASS since the 1980's

In 1999-2003 some in industry worked to remove CASS inspections from Appendix VIII via code case N-684

The NRC staff asked that the code case be tabled to allow time for additional NRC-sponsored research into the inspectability of CASS

The NRC then sponsored PNNL to examine CASS using automated conventional UT, phased-array UT, and eddy current testing, producing NUREG/CR-6929, NUREG/CR-6954, NUREG/CR-6933, and NUREG/CR-7122.

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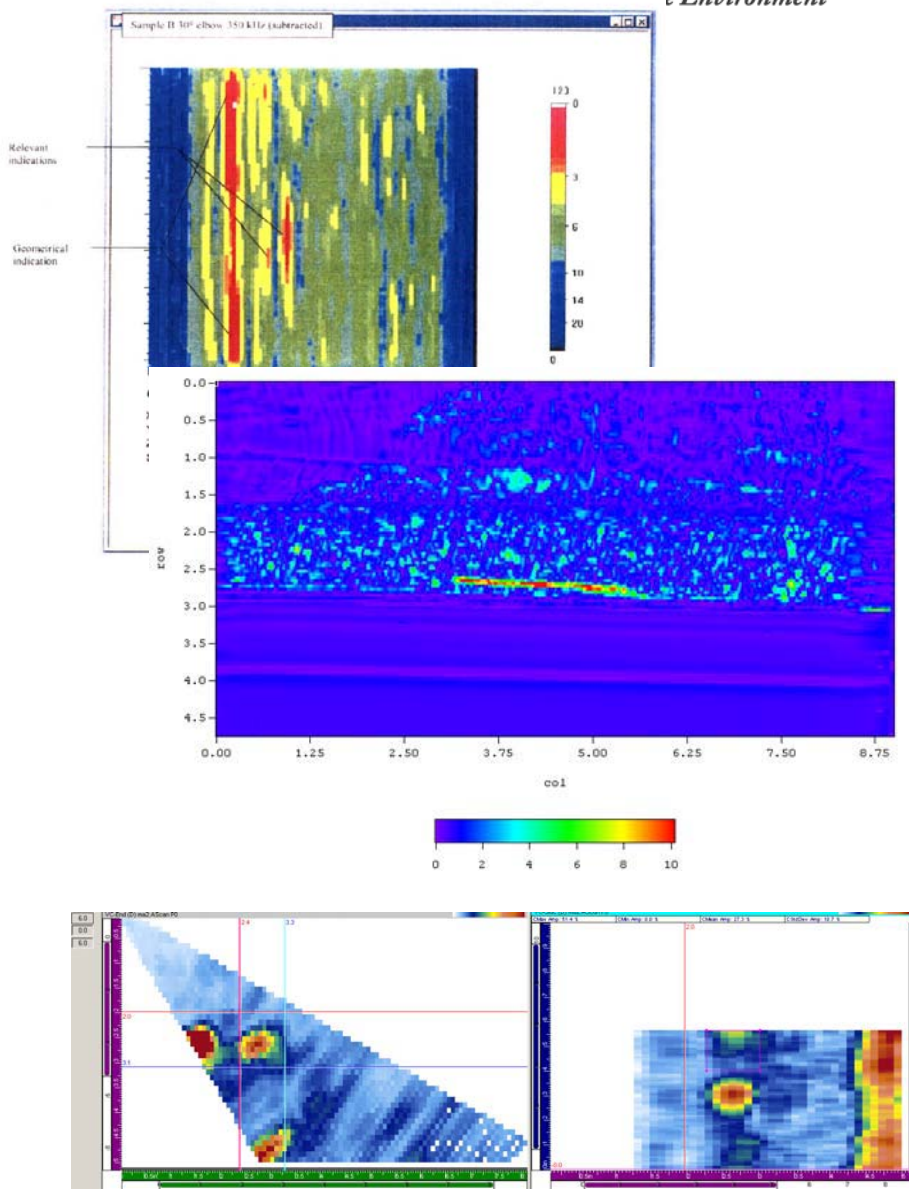
Techniques Tested

PNNL tested encoded low frequency longitudinal wave phased-array UT, Synthetic Aperture Focusing Technique (SAFT) UT and Eddy Current Testing

The effects of the larger grains can be mitigated using lower-frequency ultrasound

Phased-Array Testing proved to be more effective than SAFT UT

Eddy current was also effective



The Current State of the Art

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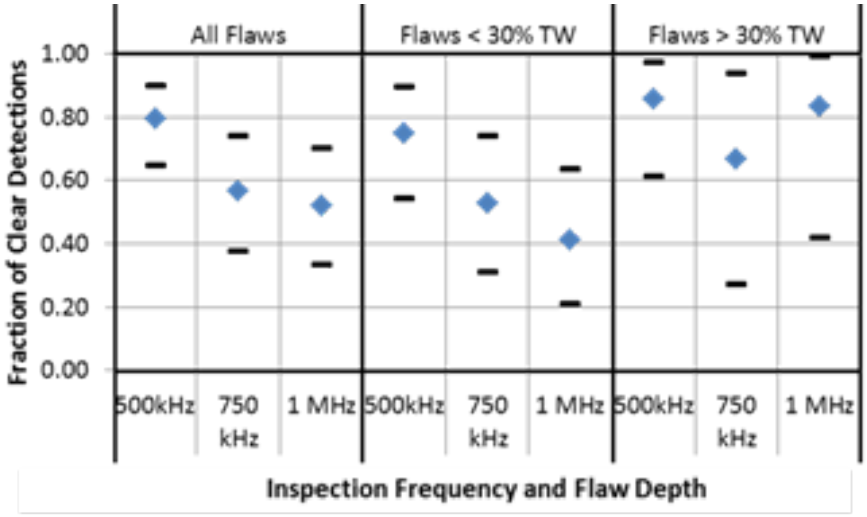
Using encoded phased-array ultrasonic methods the following things are possible:

- Reliable flaw detection in CASS components of up to 1.6 inches thick (pressurizer surge line thickness)
- Reliable detection of flaws greater than 30% through-wall in thicker (main loop piping) CASS
- Detection of flaws in CASS using ECT

What is not possible:

- Reliable detection of small flaws in CASS components greater then 1.6 inches thick using ultrasound
- Flaw depth sizing using tip diffracted signals in some CASS of greater than 1.6 inches thick



Encoded Phased Array Inspections

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The high noise from coherent scattering from grains and low signal caused by attenuation make flaw detection very challenging

Many inspection angles are needed as the grains may block some angles during the scan

The use of manual ultrasonic procedures has not been shown to be effective

Based on NUREG/CR-6933 and NUREG/CR-7122 encoding appears to be needed for an effective inspection through CASS

The use of manual phased array scanning may be possible but has never been demonstrated to the NRC staff

Problems with Low-Frequency Ultrasonic Inspections

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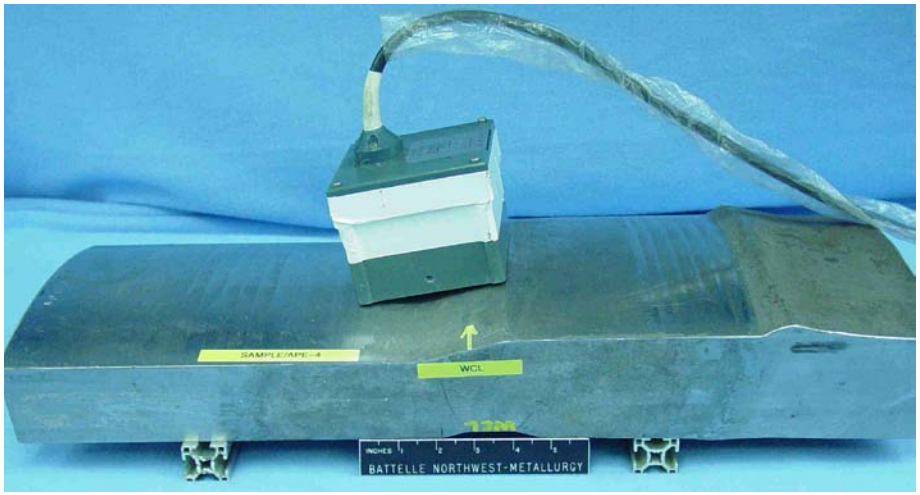
The long wavelengths that are able to penetrate CASS are relatively insensitive to small flaws

The lower frequency search units need to be relatively large to focus sound at the ID of the component, potentially reducing coverage



The Path Forward

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Developing and implementing Supplement 9 is apparently possible

Code Case N-824 was developed using the improved information on how to detect flaws in CASS

Appendix VIII Supplement 9

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Current technology may allow for the implementation of performance demonstration for CASS

A Supplement 10-style qualification would likely work for CASS components with thicknesses of 1.6 inches and less

If flaws of 30% through wall can be tolerated in thicker components, a performance demonstration test could be implemented

ASME Code Case N-824

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ASME Code Case N-824 was approved in 2012 is planned to be added to the 2015 Edition of Section XI as Appendix III Supplement 2

Code Case N-824 incorporates lessons learned from the past decades

The NRC Staff is considering adding N-824 to the upcoming rulemaking

Welds of 1.6 inches and smaller are treated differently than thick welds

- Supplement 10 qualified encoded phased array inspections may be sufficient to find 10% flaws in thinner CASS materials

Significant Improvements include:

- Guidance on ultrasonic frequencies and mode (Longitudinal waves)
- Guidance on appropriate aperture

Conclusions

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NDE Technology has improved significantly in the past 20 years

Inspections that were previously unreliable are now possible using encoded low-frequency phased array techniques

It appears to be possible to implement Supplement 9 for piping less than 1.6 inches thick and for thicker piping capable of tolerating large flaws

Code Case N-824 is a useful stop-gap until Supplement 9 is implemented