Planned NRC Research into Human Factors and Training

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Human Factors and the "Transfer Function"

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There is international interest in examining the factors that can degrade the quality of a nondestructive examination in the field vs. the results found in qualification tests

There have been sporadic efforts to look into human factors that could affect ultrasonic inspector performance in the field

The NRC has funded research into human factors issues related to ultrasonic inspections in the past and has published NUREG/CR reports on the subject

Human Factors, the Nuclear Industry, and NDE

While the industry and the NRC have focused a great deal of effort on Human Factors in relation to control room design and similar areas, NDE has received much less attention

There may be some simple improvements that can be achieved by putting the NDE and Human factors experts in a coordinated research program

Human Performance Issues in Recent Operating Experience

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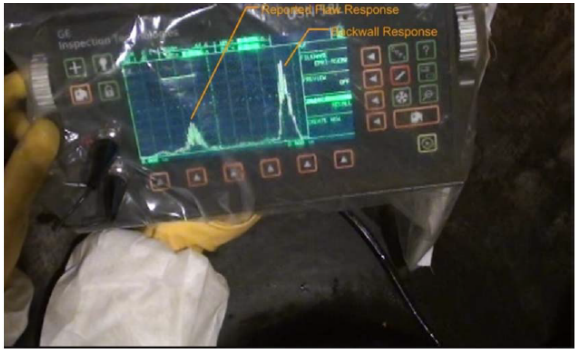
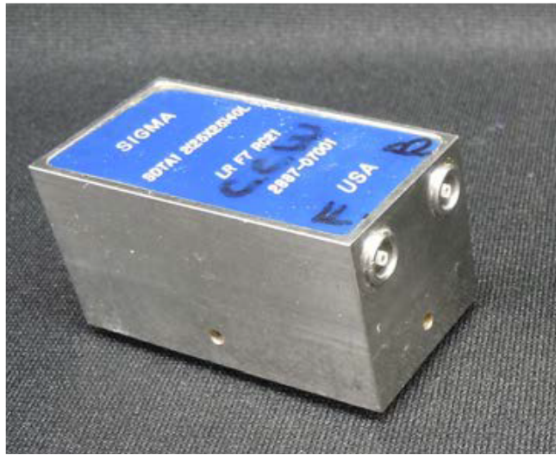
There have been recent examples of flaws missed in the field despite the fact that the procedures were capable of detecting the flaws

- Diablo Canyon pressurizer overlay welds
- Shearon Harris Control rod drive nozzle



Human factors may have played a part in the missed flaws at North Anna Unit 1 in 2012



The NRC staff believes that addressing human factors issues may provide the opportunity to improve inspections of safety-significant welds

Previous NRC Work on Human Factors in NDE

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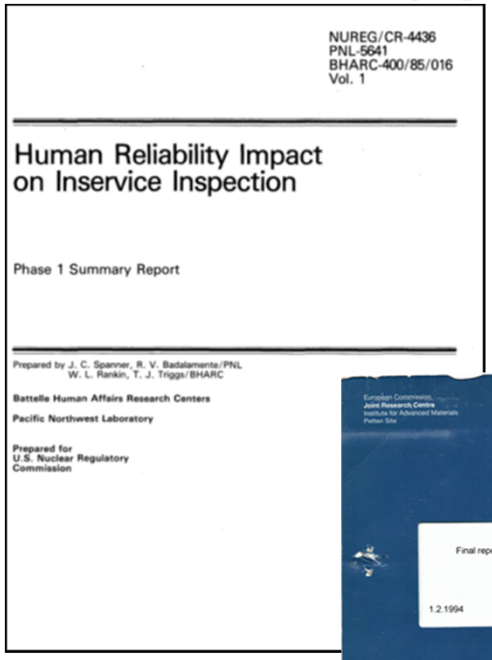
NUREG/CR-4436 from 1986 is a feasibility study conducted to identify, characterize, and evaluate the human reliability aspects of ultrasonic testing/inservice inspection (UT/ISI)

NUREG/CR-4600 from 1986 describes the results of a mini-round robin test examining human factors aspects of UT

NUREG/CR 6605 from 1998 describes the PISC III Human Factors Results


NUREG/CR-4436
PNL-5641
BHARC-400/85/016
Vol. 1

Human Reliability Impact on Inservice Inspection

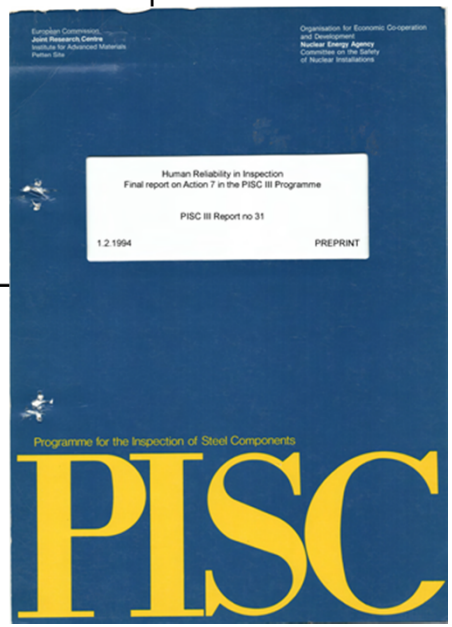
Phase 1 Summary Report

Prepared by J. C. Spanner, R. V. Badalamente/PNL
W. L. Rankin, T. J. Triggs/BHARC

Battelle Human Affairs Research Centers

Pacific Northwest Laboratory

Prepared for
U.S. Nuclear Regulatory Commission


Human Reliability in Inspection
Final report on Action 7 in the PISC III Programme

PISC III Report no 31

1.2.1994 PREPRINT

Programme for the Inspection of Steel Components

PISC

Select Results From 1986 Mini Round Robin

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No measurable difference was seen between Level II and Level III Inspectors

No fatigue effect was found when measuring performance variability in relation to operator fatigue

- Technician opinions stated that fatigue does affect their performance.
- Technician work days are much longer and much more environmentally stressing than the MRR laboratory conditions.

Detection performance for near-side, long cracks was no better than detection performance for near-side, short cracks.

Results From 1986 Mini Round Robin (cont.)

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None of the UT equipment was judged to be totally acceptable on the basis of its human engineering design characteristics

- Controls were often too small and too closely spaced
- Control scales were small and difficult to read
- Some screen designs failed to minimize reflected glare
- Screen brightness, contrast, and focus were fixed on internal controls and cannot be adjusted in the ISI environment
- Screen sizes were too small to allow good signal/noise discrimination

Flaw Detector Evolution

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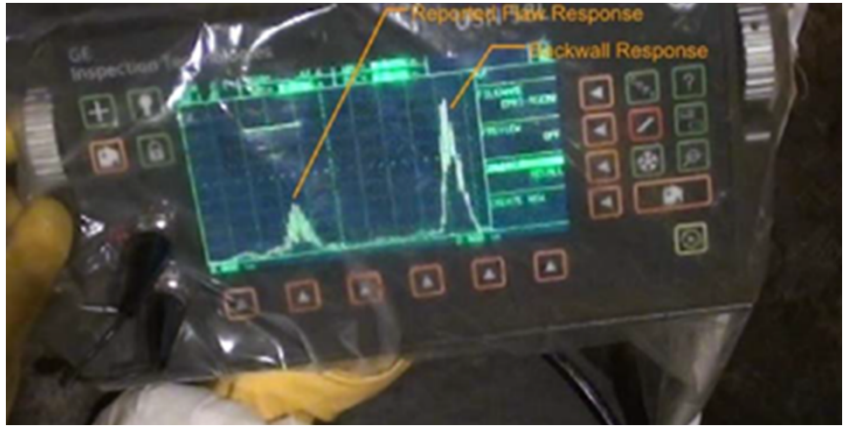
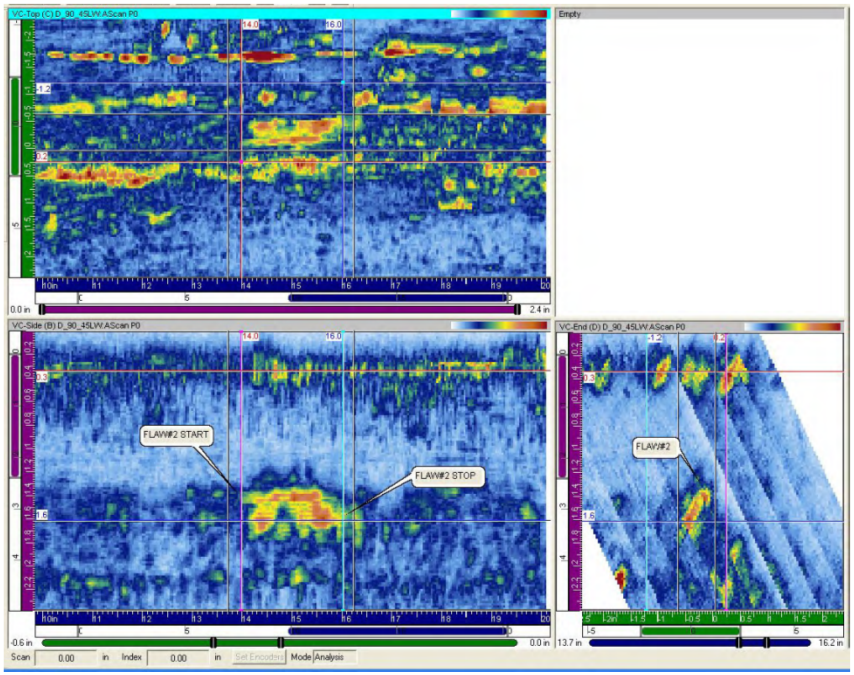
1980's

Photo credit to NC Inspection

2010's

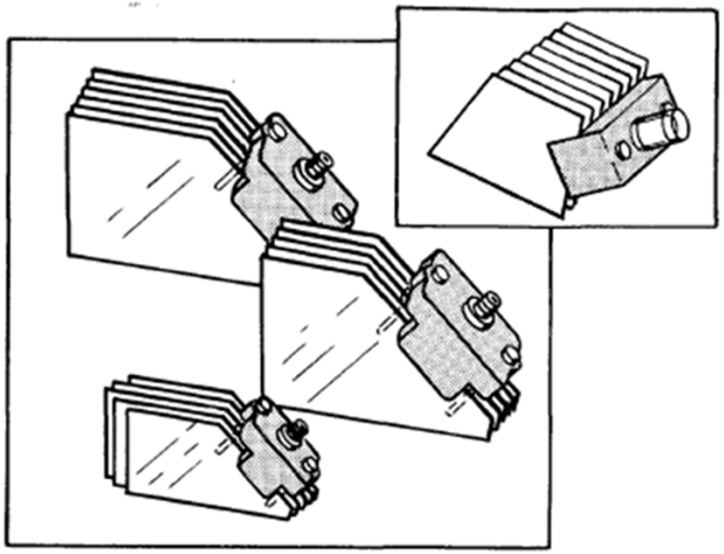




Manual Search Unit Evolution

While the piezocomposites are superior to older piezoceramics, the external designs have changed little

1980's



Angle Beam Search Units

2010's

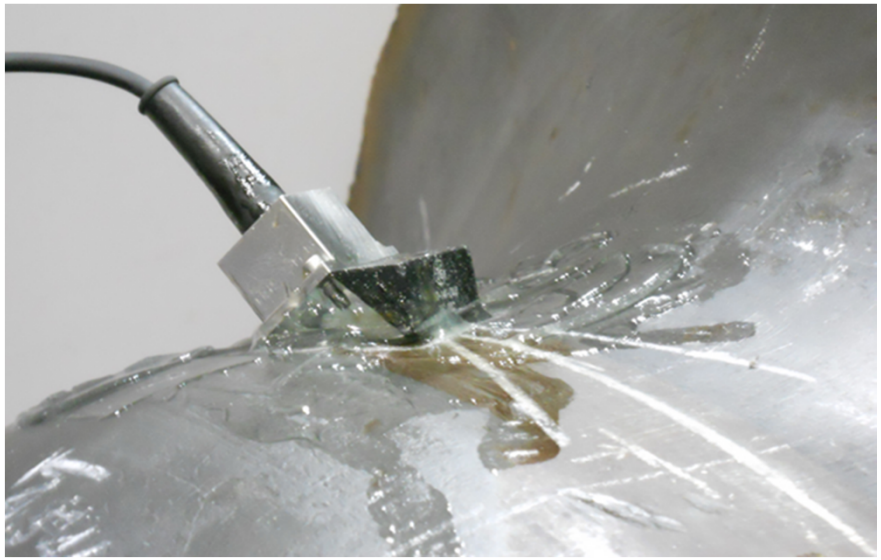


Photo Credit Mark Dennis EPRI ML113470279

Recommendations from 1986 Work

NUREG 4436 recommended a detailed Human Factors research program

- Conduct on-site field evaluations of actual inservice inspections at nuclear power plants to analyze the factors affecting human performance present during in-plant inspections.
- Evaluate and characterize the cognitive aspects of the flaw detection and sizing task elements used during UT/ISI.
- Compare Technician Training and Perceptions with Actual Performance
- Conduct Experiments to Measure and Evaluate Key Human Performance Factors

Planned NRC Human Factors Research

A cooperative program is being developed in the office of research with the Component Integrity Branch and the Human Factors and Reliability Branch

The research will focus on manual and encoded UT examinations

Task 1 is a literature review to collect existing human factors knowledge that can be applied to NDE

Task 2 will be a comparative task analysis that explores the differences between laboratory testing and field examinations

Research Goals

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Systematically evaluate the human factors issues facing NDE inspectors

Determine the key differences between laboratory qualification and practice vs. actual inspections

Determine the highest priority Human Factors issues that could be degrading NDE performance in the field

- Equipment
- Procedures
- Conditions

Develop a testing program to analyze the effects of these factors

Task 1 – Literature Review

The key goal of this literature review will be to identify and survey the body of knowledge developed in the human factors field and apply this knowledge to NDE issues. Some areas of interest include:

- A job task analysis of manual and encoded nondestructive examinations
- The effects of fatigue on performance (not NDE specific)
- How long a signal must be visible on a screen for reliable detection with different signal-to-noise ratios
- How much time is required for an analyst to accurately review large amounts of recorded data
- Possible effects of practice on inspector performance (a.k.a. the "Priming Factor")

Task 2- Comparative Task Analysis

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This task will cover directly examining the differences between laboratory scanning of mockups with field inspections of nuclear power plant components.

This comparative task analysis will involve detailed observations of laboratory practice of manual weld exams, performance demonstration testing, and field examinations of piping welds

The goal of this effort is to systematically evaluate the qualification and inspection processes to determine important differences for future evaluation

This task would greatly benefit from industry participation and partnership with EPRI

Substituting Laboratory Practice for Experience Hours

The information gathered in this effort will help the NRC staff evaluate Code Cases and training programs that would use laboratory training in lieu of experience hours

While the NRC staff recognizes that laboratory experience could be very useful in training and qualifications, the basis for substituting training for experience hours has not yet been established

The comparative task analysis in Task 2 could provide the Industry and the NRC with valuable information on the important differences between laboratory practice vs. field experience

Summary

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There is an apparent difference between the probability of detection of inspectors in qualification tests and in the field

The causes of this delta are not well understood and previous efforts to determine the causes have produced mixed results

There is a large body of knowledge on human factors that has not yet been applied to the issue of NDE

The NRC is planning on conducting a systematic investigation of the NDE process and a detailed comparison between laboratory inspections and actual inspections