WINCO-1197
January 1994

**USING YTTERBIUM-169 FOR SAFE AND
ECONOMIC INDUSTRIAL RADIOGRAPHY**

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Managed by the U.S. Department of Energy

*Prepared for the
U.S. Department of Energy
Idaho Field Office
Under DOE Contract No. DE-AC07-84ID12435*

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The author would like to express appreciation to Mr. J. Stone for his assistance in performing test radiographs and providing basic research data in the preparation of this report.

Thanks also to Mr. Bob Kelly and Mr. Fred Melmon both of Amersham Corporation for the use of their facilities and assistance in preparing this report.

Using YTTERBIUM-169 for Safe and Economic Industrial Radiography

by
James Dowalo
1/27/94

INTRODUCTION

Safety has become an issue of paramount importance for industrial radiography. Many NDE facilities and suppliers are finding the cost of performing radiography prohibitive due to heightened safety concerns for radiation area protection. The most common sources used in radiography, Iridium-192 and Cobalt-60, result in high radiation fields over a large area. Even when collimators are used large radiation fields can result from multicurie source radiography. Radiographic operations are being forced to find alternative test methods and techniques to the use of the old stand-by sources. These alternate methods are not always as comprehensive a test as full volumetric examination with radiography. Since Iridium and Cobalt are in such wide spread use, they are sometimes called upon to perform test of materials which are not in their optimum sensitivity range.

Safety regulations For the Department of Energy and local on site concerns for safe field radiographic operation at the Idaho Chemical Processing Plant prompted a search for an alternative to Iridium-192 radiography. Several papers since 1971 have cited Ytterbium-169 as requiring small radiation areas (protection zones) in field situations. Small radiation areas would provide improved safety with a smaller area to protect while reducing cost associated with the number of personnel required to maintain a radiographic area.

EQUIPMENT

Accessories to Ir-192 exposure devices are available to allow use of the same equipment for Yb-169 radiography. For our work we used Amertest 660 Projector with Yb-169 source assembly 918 and a special adapter for the guide tube to eliminate attenuation at the tip. (See fig 1 for photo of equipment setup.)

Figure 1- Photo of equipment used to make ytterbium-169 radiographs

RADIATION AREAS

Tests were conducted using a 3.81 curie 1x1 mm Yb-169 source to determine actual radiation levels existing at a typical field radiographic setup. The survey results are depicted in figure 2 and show significant reduction of radiation zone as to that compared of a 50 curie Ir-192 source under similar conditions. Iridium 192 would have radiation readings 100 times that of Yb-169.

Figure 2- TYPICAL SURVEY RESULTS WITH 3.81 ci OF YTTERBIUM-169

OPTIMUM SOURCE

During the research and testing of Ytterbium-169 sources it was realized that the energy spectrum was ideal for the majority of component thickness radiographed at the ICPP. Over 93% of all piping radiographed at the ICPP are less than .5" total thickness and under 3" nominal pipe size.

Linear absorption coefficients (Halmshaw 1981) justify x-ray equivalent performance of Yb-169 sources. Ir-192 is equivalent to X-rays in the 800 - 900 kv range, the corresponding equivalences for Yb-169 are more specimen thickness dependent and confirms Yb-169 radiations closely match X-ray ratings normally used in practical x-ray examination of steel. See figure 3 for a comparison of Yb-169 and X-ray recommendations found in ASME Sec V.

<u>THICKNESS OF STEEL</u>	<u>Yb-169 kv</u>	<u>ASME SEC V kv</u> <u>MAXIMUM FOR STEEL</u>
0.08" (2.0 mm)	125	125
0.2" (5.0 mm)	160	190
0.4" (10.0 mm)	195	330
0.6" (15.0 mm)	280	480

Figure 3- Comparison of Ytterbium-169 and X-ray optimum energy for exposures.

Radiographic techniques were shot to evaluate the quality of radiographs produced with Ytterbium-169. The table below shows technique parameters used and ASTM E-142 penetrameter sensitivity achieved.

RADIOGRAPHIC TECHNIQUES

TECHNIQUE & COUPON DESCRIPTION	SFD	PENE	EXPOS TIME	FILM H&D	RATING
No.2 Step wedge blocks one each: Hastalloy; Nitronic 50; Carpenter 20; and 304 Stainless Steel	6"	5/7	5 min	ok	high contrast & definition
No. 4s Elliptical exposure; ½" sch40 SST	6"	7	13 min	2.7	1-T IQI sensitivity
No. 8 Panoramic exposure; 2" sch40 pipe SST	1- 1/8"	F7	5 min		2-T IQI sensitivity

Figure 4- Radiograph of step wedges illustrating the high contrast and high definition radiographs achieved with Yb-169 source. (Photograph is negative of radiograph).

CONCLUSIONS

Ytterbium-169 sources can be used to replace Iridium sources for radiography of steel less than .5" thickness with improved safety and reduced cost. Any time the size of a radiography radiation zone can be reduced, improved safety is the result. Reducing the number of exposures required to cover a particular item radiographed also has its impact on improving safety by avoiding additional exposures of the

sources within their range of material size and thickness can be realized if careful planning is performed. Radiographic personnel would have to be trained in the use of Ytterbium sources and given the opportunity to practice with the source to become proficient in economic application of its use.

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APPENDIX A

APPENDIX A

The Fuel Processing Restoration (FPR) project was designed to replace most of the chemical reprocessing facilities at the ICPP. Piping fabrication estimates for this project were used to estimate how often Yb-169 sources could be used in the course of piping examinations. The results are tabulated below.

DESCRIPTION	THICKNESS	QUANTITY	% TOTAL
Pipe welds 3" and smaller	Schedule 40	28,062	41%
Pipe welds 2" and smaller	Schedule 80	35,675	52.5%
Pipe welds 1½" and smaller	over sch 80	1151	1.7%
Total welds applicable Yb-169		64,888	95%
Total welds greater than 2"	all sch	13,702	20%

62% of all welds were estimated to be radiographed for the project. If only half of the welds 2" and larger were radiographed using panoramic exposures then 13,702 separate exposures would be saved. This would save 27,404 pieces of film costing approximately \$125.00 per box of 100 film. The total film savings equals \$34,250.00 for panoramic exposures. This savings does not consider the avoidance of generating waste chemicals from film processing which would require disposal.

When establishing radiographic areas in the field using Ir-192 experience at the ICPP has indicated that an average of 1.5 barrier guards in addition to the radiographic crew are needed to assist in keeping people out of the radiation and high radiation areas. Assuming approximately .5 hours of field operation time for each weld radiographed and 12,538 field radiographic welds, then 6,269 field radiographic operation hours would be required for the FPR project. If one-third of the barrier guard monitors could be avoided due to the reduced size of the radiation field when using Yb-169 source instead of Ir-192, then approximately \$156,725.00 could be saved in field radiography cost during the course of the project lasting four years.

Ytterbium sources cost approximately \$5000.00 for a 1x1 mm source at 7 to 10 ci. Iridium sources, on contract, cost \$750.00 each for 100 ci. .1x.1 inch source. Ytterbium half life 32 days can effectively be used around 3 half life cycles, there fore requiring a new source about every 3 months. Iridium is presently being ordered at the ICPP on a 3 month cycle to ensure two cameras are maintained with sources of usable and efficient strength to perform radiography. To maintain one Yb-169 source at all times ready for use would cost \$20,000.00 per year or \$80,000.00 for the full course of the FPR project.

It can be easily seen that just by adding the use of Ytterbium to the FPR project that over \$110,000.00 could be saved in radiography cost while enhancing the quality of radiography and reducing radiation exposure hazards.