T-Flex® Engineered ALARA Solutions

npo®
A BRAND OF
EICHROM TECHNOLOGIES

Dose Rate Reduction

We've visited the plants.

We've built **transparent** and **trusting** relationships with RP customers.

We work with the right tools for simple and complex jobs.

We own a rich **history** and are **global** market leaders.

Now, we are bringing you the stories, the solutions, the results.

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Contents

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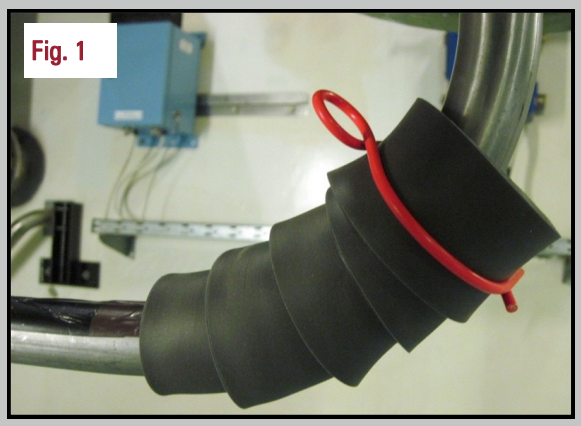
Fig. 1

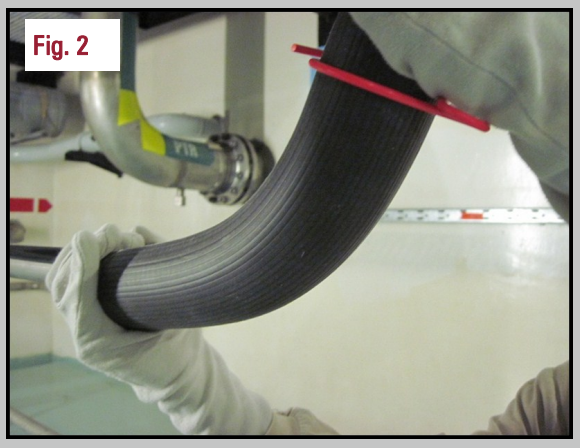
Fig. 2

Fig. 3

Belleville Nuclear Power Plant

Challenge: Belleville conducted attenuation testing on pipes with and without T-Flex® protection.

Solution: Results proved the effectiveness of T-Flex® **(Figs. 1—4)**.

Key:

Fig 1: Without T-Flex®: 2,6 mSv/h
With T-Flex®: 0,50 mSv.h
Attenuation Factor > 5

Fig. 2: Without T-Flex®: 2,6 mSv/h
With T-Flex®: 0,36 mSv/h
Attenuation Factor > 7

Fig. 3: Without T-Flex®: 16.15 mSv/h contact

Fig. 4: With T-Flex®: 1.15 mSv/h contact

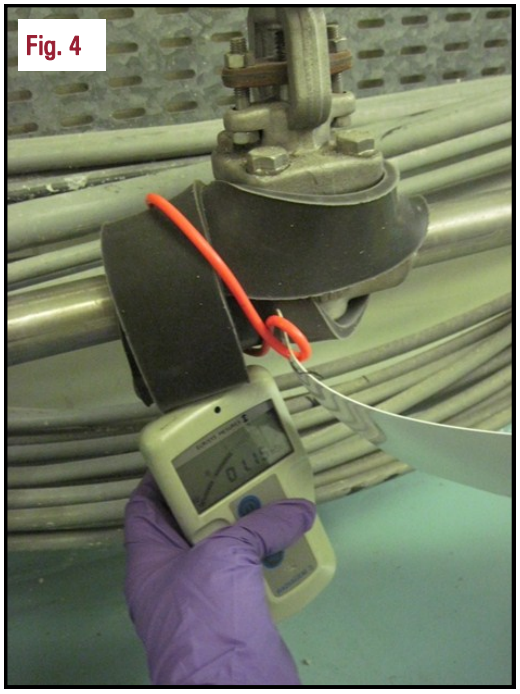
Fig. 4

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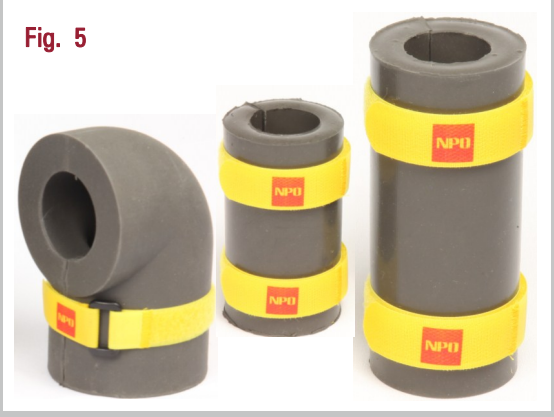
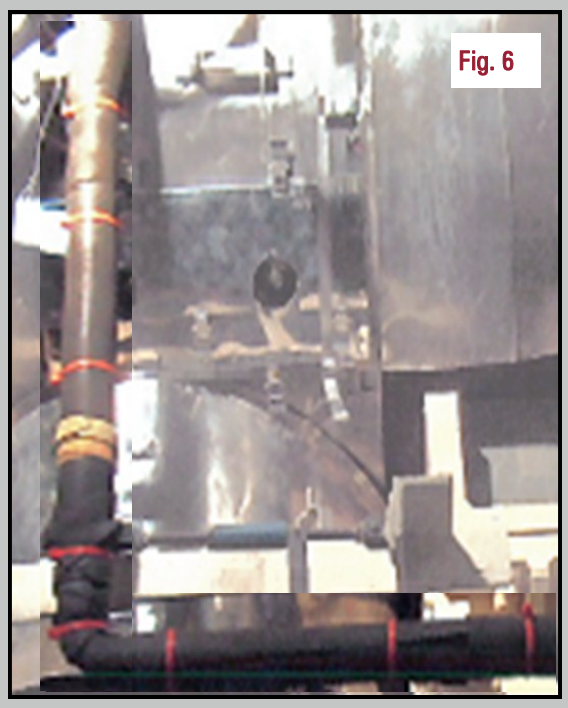
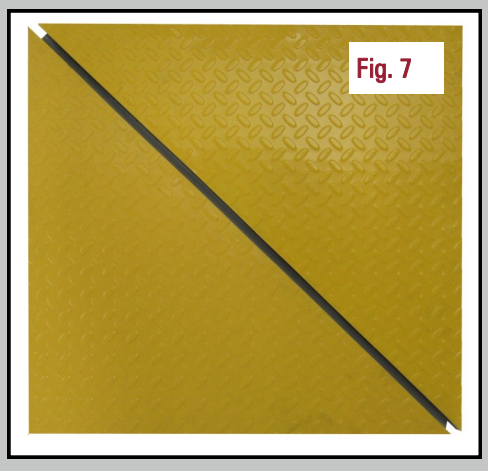
Fig. 5







San Onofre Nuclear Generating Station

Challenge: San Onofre wanted to decrease dose from small bore piping adjacent to where maintenance and inspection work is performed. The 3/4 inch (1.9 cm) pipe is challenging to shield with lead blankets.

Solution: Using NPO T-Flex® tungsten/silicone shielding, we manufactured 65 form-fitting 3/4 inch (1.9 cm) and 1-1/2 inch (3.8 cm) diameter pipe shields **(Fig. 5)** for San Onofre, meeting their 10 pounds per linear foot weight allowance.

Results: San Onofre achieved 65 percent attenuation with approximately 5/8 inch (1.6 cm) thick high density T-Flex® **(Fig. 6)**. Because this shielding is quick and easy to install, workers now incur a much lower installation dose.

Salem Nuclear Power Plant

Challenge: Salem needed to reduce dose incurred below the work platform during dry cask fuel storage activities.

Solution: NPO created T-Flex® iron-based ergonomic flooring material **(Fig. 7)**, which provided a half-layer value of shielding as well as a non-slip diamond-deck pattern for added worker safety.

Results: Workers were able to work more comfortably and received 100mR less dose (collectively) over three campaigns.

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Fig. 8

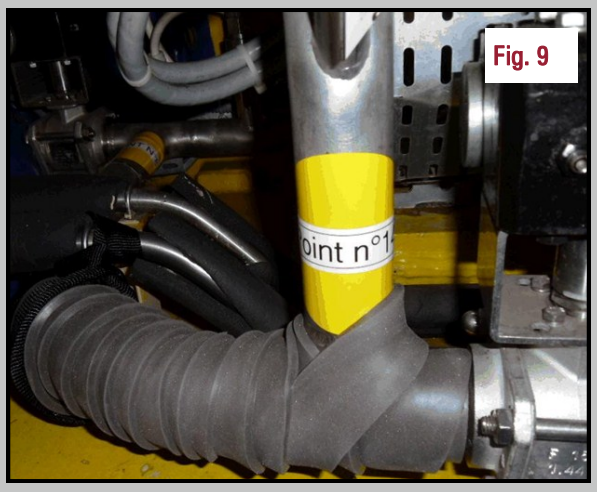

Fig. 9

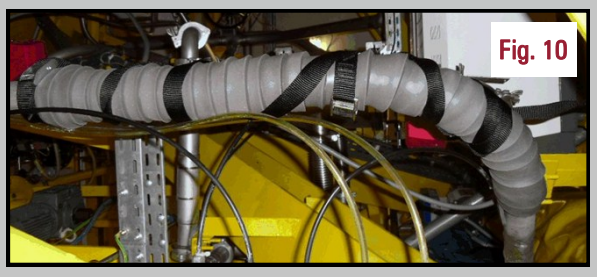
Fig. 10


Fig. 11

Cattenom Nuclear Power Plant

Challenge: Cattenom had a trolley for unloading fuel with highly radioactive pipes. A significant number of plant workers received an average dose of 350 μSv/h during the unloading process. Lead blankets were an inefficient means of protection for this application.

Solution: NPO supplied Cattenom 2438 X 51 X 6 mm (or 96 X 2 X .25 in) of T-Flex® ribbon wrap. **(Figs. 8—11)**.

Results: Cattenom's ambient dose rate dropped from 350 μSv/h to 120 μSv/h.

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Fig. 12

Fig. 13

Fig. 14

Calvert Cliffs Nuclear Power Plant

Challenge: Calvert Cliffs was not effectively shielding welders from hot spots during work on the pressurizer.

Solution: Using T-Flex®, NPO contoured the shielding **(Figs. 12—14)** to fit the mechanical and electrical interface where hot spots **(Fig. 15)** were the main problem on the heater assemblies.

Results: The new T-Flex® was installed in 1/3 of the time, at less weight and for the same cost as lead clamshell shielding, cutting the dose by 65 percent.

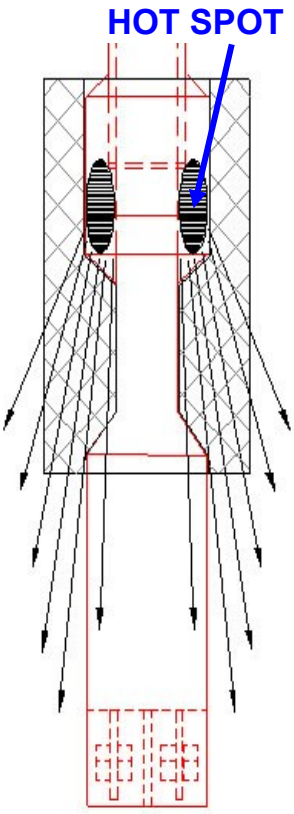


Fig. 15

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Fig. 17

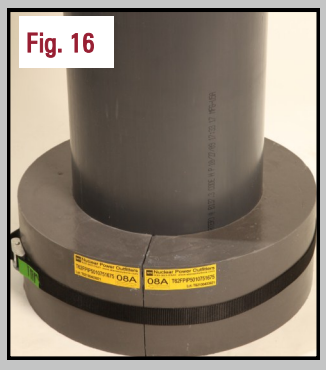
Fig. 16

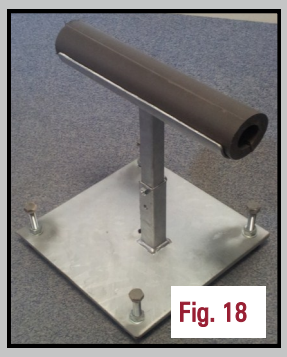
Fig. 18


Fig. 19


Fig. 20

Oconee Nuclear Station

Challenge: Oconee technicians were incurring up to 900 mrem during outages from vertical letdown piping located in the reactor building basement.

Solution: NPO designed stackable tungsten blended shield collars **(Fig. 16)** to wrap around the source **(Fig. 17)**.

Results: Oconee technicians were able to install shielding in a record low time of 35 minutes and received a record low dose of 135 mrem during installation.

Gravelines Nuclear Power Plant

Challenge: Gravelines has tubing and valves with hot spots. The lack of support at the end of the tube makes shielding the tube difficult, resulting in dose to plant workers during maintenance operations.

Solution: NPO designed an adjustable support **(Fig. 18)** that works with T-Flex® ribbon wrap and pipe shields to provide adequate shielding without compromising the tube.

Key:

Fig. 19: The valve without the shield

Fig. 20: The valve with the shield

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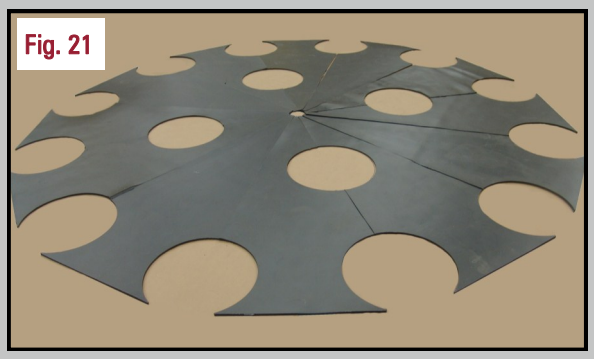
Fig. 21


Fig. 22

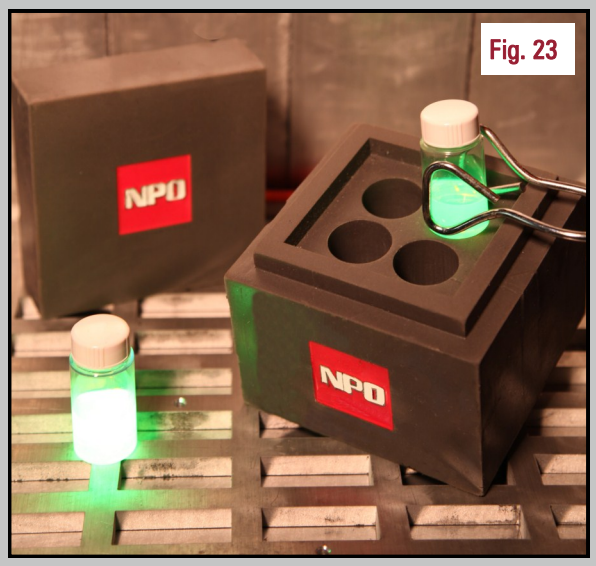

Fig. 23

Surry Power Station

Challenge: Surry wanted to create a cost effective, low-profile shield that could be easily installed on the steam generator lower deck plate.

Solution: An NPO T-Flex® tungsten and iron blended product **(Fig. 21)** was created to provide the required shielding within budget and material thickness constraints.

Results: The 1/2 inch NPO T-Flex® shields were rolled up and taken down from the manway to the lower deck plate in slices and then rolled out to cover the decking **(Fig. 22)**. The custom fabrication of these pieces allowed for overlapping pieces to reduce streaming by cutting at 45 degree angles to one another. Overall, Surry estimates they saved 4Rem collectively for their feed ring replacements at both units.

Argonne National Laboratory

Challenge: Argonne was looking for a benchtop shielding solution for TRIGA reactor sample vials.

Solution: NPO designed a tungsten-based four vial shield **(Fig. 23)**, which provided at least 3cm of shielding in each direction when closed.

Results: The T-Flex® storage solution reduced dose from bench top samples by approximately 85 percent.

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Fig. 24

Peach Bottom Nuclear Generating Station

Challenge: Peach Bottom needed additional shielding for underwater divers working on core-spray piping repairs.

Solution: Using cleanroom techniques, NPO manufactured T-Flex® with high precision **(Fig. 24)** to minimize leachable components.

Results: General Electric tested **(Table 1)** the NPO T-Flex® product for use in flood-up water and approved its use based on the low levels of leachable halogens.

Table 1

The sample of T-Flex® shielding was submitted for analysis to ensure compliance with GE Specification NEDC31735P, rev. December 2000. Duplicate portions of the sample were prepared for analysis by performing a Parr bomb oxidation. The resultant solutions were analyzed by ion chromatography for total halogens and total sulfur and by inductively coupled plasma spectrometry for total embrittling metals. The sample was also prepared for analysis by performing a 48-hour extraction with demineralized water. The resultant solutions were analyzed by ion chromatography for total nitrite and total nitrate.

Parameter	2010913	Acceptance Criteria	Test Method
Total Halogens as Cl, ppm	47	450 max	ASTM D4327-03
Total Nitrite, ppm	<1	10 max	ASTM D4327-03
Total Nitrate, ppm	<1	820 max	ASTM D4327-03
Total Sulfur, ppm	83	630 max	ASTM D4327-03
Total Combined Level	3.0	13.2 max	CALCULATED
Total Antimony, ppm	16	200 max	ASTM D1976-07
Total Arsenic, ppm	<1	200 max	ASTM D1976-07
Total Bismuth, ppm	<1	200 max	ASTM D1976-07
Total Cadmium, ppm	<1	200 max	ASTM D1976-07
Total Gallium, ppm	<1	200 max	ASTM D1976-07
Total Indium, ppm	<1	200 max	ASTM D1976-07
Total Lead, ppm	<1	200 max	ASTM D1976-07
Total Mercury, ppm	<1	200 max	ASTM D1976-07
Total Silver, ppm	15	200 max	ASTM D1976-07
Total Tin, ppm	<1	200 max	ASTM D1976-07
Total Zinc, ppm	7	200 max	ASTM D1976-07
Total Embrittling Metals, ppm	46	500 max	ASTM D1976-07

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SYSTEM CERTIFICATION ISO 9001:2008 SGS

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Comparing T-Flex® and Lead at Different Gamma Energies

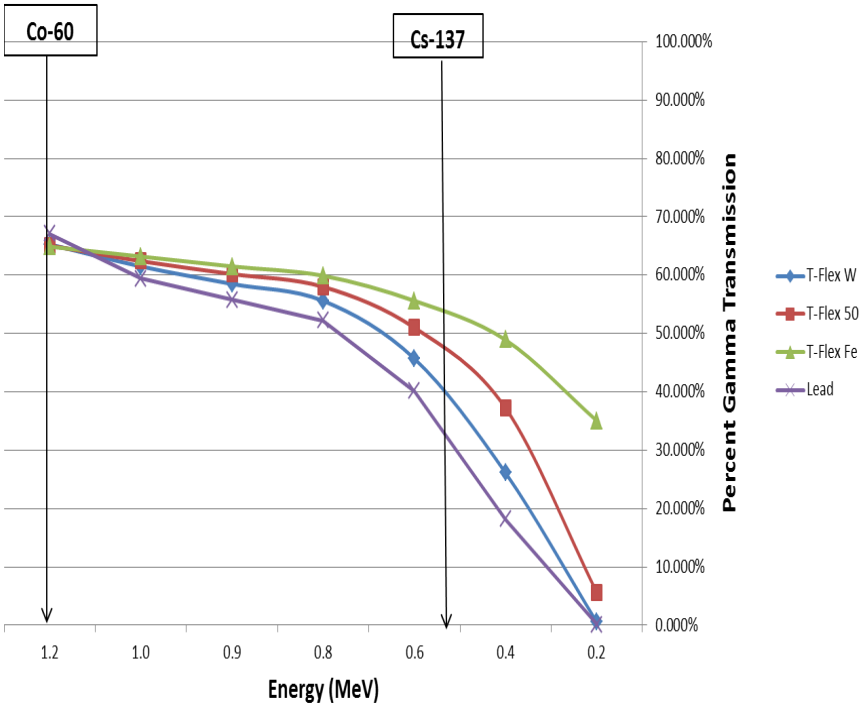
Energy MeV	T-Flex® W Transmission	T-Flex® 50/50 Transmission	T-Flex® Fe Transmission	Lead Transmission
0.2	0.518%	5.61%	35.0%	0.0667%
0.4	26.1%	37.2%	48.9%	18.2%
0.6	45.7%	51.0%	55.6%	40.1%
0.8	55.6%	58.0%	59.9%	52.2%
0.9	58.5%	60.2%	61.5%	55.8%
1.0	61.5%	62.4%	63.2%	59.4%
1.2	65.3%	65.1%	64.9%	67.1%
Cs-137	47.9%	53.3%	57.8%	43.8%
Equal Mass In-the-Path Basis				
Thickness (in)	0.41	0.80	1.10	0.25
(mm)	10.34	20.26	27.90	6.46
Density (g/cc)	7.08	3.61	2.62	11.34

T-Flex® Vs. Lead

100% iron (FE) | 50/50 (by weight) tungsten & iron | 100% tungsten (W)

The T-Flex® pucks illustrated above are all of equal weight. The thicknesses of the material in the path of the gamma radiation has been adjusted to provide an equal "mass-in-the-radiation-path." Note the similarity of the gamma transmission percentage at 1.2 MeV, which is approx. that of Cobalt-60.

Equal Mass Transmission for NPO T-Flex® Materials Compared With Lead at various Gamma energies (lead equivalent to standard lead blanket)



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