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memorandum

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Nuclear Engineering and Nonproliferation Division
International Threat Reduction Group NEN-3
Off-Site Source Recovery Project (OSRP)

SUBJECT: **Monsanto Research Corp. Model 24141 Special Form Re-Evaluation**

SCOPE

The purpose of this memo is to characterize Monsanto Research Corp. model 24141 radioactive sealed sources as US DOT Special Form Radioactive material, with the goal of achieving, shipment, consolidation, interim storage, and final disposition at WIPP.

DOCUMENTATION

In May 1975, Monsanto Research Corp. did not apply for a USDOT Certificate of Competent Authority (COCA), which would have been required for international shipment. Instead, MRC self-certified the special form status of their model 24141 sealed source as allowed by regulation. The model 24141 is a neutron source (AmBe) containing 1 Ci of Am-241 isotope for use in Ohmart fixed nuclear gauges. The only documentation we have of the Ohmart device is a drawing of very poor quality (A-26202).

PHYSICAL FEATURES OF THE MODEL 24141

The model 24141 sealed source is a cylindrical double encapsulation made of welded 304 stainless steel. Approximate outer dimensions are 15.9 mm (0.625 in.) in diameter and 254 mm (10 in.) in length. Construction is in accordance with MRC drawing numbers A24141-AA00. Wall thickness of the cylindrical tubing was a nominal 1.24 mm (0.049 inches). The minimum weld thickness for attaching head to cylindrical tube is 0.020 inches. The head pieces were about 18.4 mm (0.725 inches) thick with a ¼-28NF x 0.5 inch thread hole on both ends of the outer capsule (see attached drawing).

Radioactive contents were limited to 37 GBq (1 Ci) of Am-241. This neutron source contained a mixture of beryllium metal and americium oxide. The beryllium and americium were in a ratio of 4.5:1.0, respectively.

SPECIAL FORM ANALYSIS

The special form analysis for MRC model 24141 is documented in MRC manufacturing order 1029-5 from May 1975 (TWCP-07489, Attachment A). The special form evaluation relied upon previous testing of the MRC source models 24148 and 2493-G source with 203 mm and 280 mm of length, respectively. MRC source models 24148 and 2493-G sources were granted COCA USA/106/S and USA/128/S, respectively.

MRC lead mechanical engineer evaluated the minimum possible theoretical dimensions of the source components and the corresponding minimum source internal volume, a gas volume (He-4) for total decay from the alpha emitting isotope was calculated. The pressure generated by the emitted gas in the calculated internal volume at a maximum test temperature (800 degree C) was then calculated. Mechanical stress in the walls, head, and welds of the source cladding were calculated using the ASME Pressure Vessel code with a safety factor of 4. The model 24141 source was found to be able to maintain the safety factor of 4 for a minimum of 20 years of source life time.

At least three potential sources of excess conservatism exist in these engineering calculations of special form character for the model 24141. The excess conservatism is found in the clad weld thickness, an arbitrary 20% reduction in service life, and the ASME pressure vessel code safety factor of 4. These conservatisms exist because of the philosophy of MRC methods used to demonstrate USDOT special form character. If the real case is re-examined and the degree of conservatism is re-evaluated, then special form character may be established for these 40+ year old sources.

The model 24141 minimum clad weld thickness was specified at 0.020 inches for both capsules. The nominal clad wall thickness (t_w) is 0.049 inches. The clad head piece has a chamfer of 0.020 inches to simplify the problem of generating a minimum weld thickness of 0.020 inches. MRC engineer Edward Janzow goes on to calculate the maximum pressure during an 802 degree centigrade fire after 20 years of alpha decay to be 63.1 psi. Dr. Janzow goes on to calculate the minimum required weld thickness to be 0.009 inches with a safety factor of 4. Since the minimum weld penetration (0.020 in.) is double that minimum required weld thickness, The service life can be extended by a factor of 2 (2x20 yr) from this one factor (see Table A).

Table A. Minimum required weld Penetration for limiting Head stress in the model 24141 source

Temperature (°C)	Max Internal Pressure (psi)	Actual Pressure (psi), after 20 years decay	Required Weld Penetration (inches)
21	1,032	17	0.0008
204	712	28	0.002
802	437	63	0.007

Note that the calculated minimum weld thickness is approximately one third of the minimum required weld penetration after 20 years of decay and at the Special form thermal test temperature of 800 °C.

Dr. Janzow also calculates the maximum allowable internal pressure limited by Head stress, Circumferential Hoop stress, and Longitudinal stress for the source clad (see Table B).

Table B, Maximum Allowable Internal Pressure, Limited by Stress

Stress Type	Max Allowable Pressure (psi)
Head Stress	437
Circumferetial Stress	1,331
Longitudinal Stress	3,200

This Table B demonstrates that Head Stress is the limiting mode of failure for this capsule design.

The ASME Pressure Vessel code safety factor is applied to the overall calculation. The safety factor is a factor of 4.0. The ASME Pressure Vessel code is designed to prevent injury, loss of life, and significant facility damage if a large pressure vessel fails. The ASME code was specifically developed to prevent steam boiler explosions common prior to the turn of the 20th Century in locomotive and facility boilers. It can be argued that this code is unnecessarily conservative in that the failure of a small sealed source which will not cause the type of damage (energetic shrapnel) that can accompany a boiler explosion.

An arbitrary 20% decrease in service life was also applied to the original service life calculation. This 20% reduction was not justified by any engineering calculation. The reduction purely reflects the risk adverse character of the MRC Management in 1975.

If the safety factor required was 2.5 this would reflect a 60% increase in service life. High integrity of the nominal weld thickness would offer a 200% increase in service life. Eliminating the arbitrary 20 percent reduction in service life that was part of the MRC risk aversion philosophy adds 20% to the service life. In total these increases in service life (2.0 + 0.6 + 0.2) total to a 280% increase in service life (56 yr). It can logically be argued that the original 20 year recommended working life calculated by MRC engineers is in fact a 56 year recommended working life simply by removing some of the excess conservatisms in the original calculation.

SUMMARY

The MRC model 24141 sealed source is very similar to other MRC sealed radioactive sources intended for use in Ohmart fixed moisture density gauges (MRC 24148 & 2493-G). Examining the basis of the original service life calculation clarifies the inherent conservancy of the original engineers and emphasizes the safety of these neutron sources 40 years after manufacture.

CONCLUSION

The MRC model 24141 radioactive sealed source as documented in the manufacturing order and drawings can be self-certified as US DOT special form radioactive material, within the limits and scope of this memo until June 1, 2015, a RWL of 40 years. After June 1, 2015 all MRC model 24141 radioactive sealed source shipped by OSRP need to be re-encapsulated in OSRP Special Form capsules.

Encl.:

A.TWCP 07489, Special form engineering analysis by Dr. Edward Janzow, MRC

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