MASTER

PM-1 TECHNICAL MEMORANDUM
SELECTION OF 347 STAINLESS STEEL FOR USE
IN THE PM-1 REACTOR PRESSURE VESSEL

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Selection of 347 Stainless Steel for Use in the PM-1 Reactor Pressure Vessel

The criteria governing the selection of material for the PM-1 pressure vessel were that:

1. No appreciable material ductility change should occur due to neutron bombardment;
2. The material should be an ASME Code Material

A study program of nuclear irradiation effects on martensitic, ferritic, and austenitic steels was conducted. The results of this study showed that the austenitic stainless steels are the least effected by neutron bombardment. Small amounts of ferrite are expected to precipitate during irradiation, but should have insignificant effects on service performance. Complete results of the irradiation study contained in PM-1 Technical Memorandum, MND-M-1901, dated November, 1959.

This investigation treats the reasoning involved in the selection of Type 347 stainless steel to conform to ASME Specification SA 240 as the austenitic steel to be used in the pressure vessel. The austenitic stainless steels acceptable to the ASME Boiler and Pressure Vessel Code are tabulated in Table I, which also contains the material specification number, carbon content, maximum allowable stress at 600 F, and minimum required wall thickness to accommodate vessel design pressure and temperature.

The chemistry, mechanical properties, welding characteristics, and corrosion resistance of each type of steel was evaluated.

All material that are included in ASME Specification SA167 were rejected because of possible high carbon contents. Non-stabilized steels in this group would have a greater tendency to precipitate chrome carbides during welding. This precipitation lowers corrosion resistance of the material in the heat affected zone. It is, therefore, recommended that the more stringent chemical requirements of ASME Specification SA240 be used for the vessel material.

Types 309, 309S, 316 and 317 were rejected due to their molybdenum content. Molybdenum is a strong ferrite former in these austenitic stainless steels particularly in weld zones. Irradiation can cause appreciable loss of ductility and increase in corrosion in ferrite containing zones.

The high alloy types 310 and 310S were never considered because of their susceptibility to carbide precipitation during welding.

The metallurgical methods for controlling carbide precipitation are (1) lowering the carbon content or (2) the addition of a stabilizer. Types 304L and 316L have low carbon content (.03% max.) while type 321 (Titanium), type 347 (Columbium) and type 348 (Columbium) are stabilized.

Since weight (wall thickness) is an important factor, the following types were rejected: 302, 304, 304L and 316L. Types 302 and 304 would required a minimum vessel wall thickness of 2.97 inches, A 4.18 inch wall thickness is required for type 304L and a 3.7 inch minimum wall thickness for type 316L.

A stabilized austenitic stainless steel was recommended. Type 347 was selected because the stabilizer, columbium, is not

lost in welding. Titanium, the stabilizer in type 321 is not retained during welding.

It should be noted that type 348 is identical to type 347 except that the tantalum content is controlled to 0.10% maximum. This control has no effect on mechanical properties but does influence the radioactivity induced in the material.

TABLE I

AUSTENITIC STAINLESS STEELS
ASME CODE MATERIALS

Specifi- cation No.	Type	Carbon Content	Allowable Stress At 600°F PSI	Reason for Rejection	Minimum Vessel Thickness In Inches
SA167	302	.08 to .20	11600	Low Strength	2.97
SA240	302	.15 Max.	11600	Low Strength	2.97
SA167	304	.08 Max.	11600	Low Strength	2.97
SA240	304	.08 Max.	11600	Low Strength	2.97
SA240	304L	.03 Max.	9000	Low Strength	4.18
SA167	309	.20 Max.	16500	Moly Content Resulting in Ferrite Formation	1.92 1.92
SA167	310	.25 Max.	17200	Carbide Precipitation	1.83
SA240	310S	.08 Max.	17200	During Welding and Resultant Corrosion	1.83
SA167	316	.08 Max.	17100	Moly Content	1.84
SA240	316	.08 Max.	17100	Moly Content	1.84
SA240	316L	.03 Max.	10150	Low Strength	3.50
SA240	317	.08 Max.	17100	Moly Content	1.84
SA167	321	.10 Max.	14900	Stabilizer lost during welding	2.18
SA240	321	.08 Max.	14900	Stabilizer lost during welding	2.18
SA167	347	.10 Max.	14900	High Carbon	2.18
SA240	347	.08 Max.	14900	Selected	2.18
SA240	348	.08 Max.	14900	Availibility	2.18