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CHECK VALVE REQUIREMENTS ANALYSIS
(PRELIMINARY)

SODIUM VALVE TECHNOLOGY PROGRAM

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FOREWORD

This analysis is an outline of all the requirements incumbent upon large valves for use in an LMFBR heat transport system in the primary and secondary sodium loops. It contains all the requirements set forth in the work statement of the LMFBR Large Valve Technology Development Contracts R.F.Q. dated 28 March 1969 plus additional known requirements based on previous AGC valve design and development contracts. The intended use of this outline is threefold:

1. To provide a check list for use in composing the valve design specification.
2. For use as a check list, or in preparation of a check list for design review.
3. For use as a reliability check list or in preparation of a reliability check list.

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CHECK VALVE REQUIREMENTS

In the design of the valves used in the Sodium Valve Technology Program the following factors shall be considered. This list should not be considered complete and any review or consideration of a particular design should not be limited to only those items listed.

1. Specifications and Standards Requirements

1.1 RDT Specifications and Standards, Preferred.

1.2 Alternate Specifications and Standards - acceptable upon customer approval; ASME, ASTM, ASA, Federal, DOD, Military, AGC, or other, as applicable.

1.3 Standard Parts Use

1.4 Standard Tools

1.5 Design Standards

2. Materials and Processes Requirements

2.1 Structural Materials and Working Fluid

2.1.1 Radiation Effects

2.2 Synthetic Materials (operators)

2.2.1 Radiation Effects

(a) Na radiation level - 1,000,000 r/hr gamma.

2.3 Fungus-proof Materials (Instrumentation)

2.4 Lubricants

2.4.1 Radiation Effects

(a) Na radiation level - 1,000,000 r/hr gamma.

2.5 Dissimilar Materials

2.6 Corrosion and Erosion Resistance

2.7 Protective Treatments

2.7.1 Plating

2.7.2 Hardfacing

2.7.3 Passivation

2.8 Casting

2.9 Forging

2.10 Heat Treatment

2.11 Welding

2.11.1 Qualification and Inspection per ASME Boiler Code, Section IX.

2.11.2 Process Standards

TIG

MIG

Gas

EB

2.12 Brazing

2.13 Surface Finish

2.14 Cleaning Requirements:

Raw Stock

In process

Prior to Assembly

Prior to test

In Storage

Prior to Delivery

Prior to Installation in Sodium Service

Post Sodium Service

2.15 Materials Problems

Self Welding

Galling

Mass Transfer

Carburization by Molten Sodium

2.16 Materials General Requirements

(a) Materials in the valves shall be suitable for service in 1200°F sodium systems containing 300-series austenitic stainless steels, higher nickel austenitic stainless steels, and ferritic (Cr-Mo) steels. The determination of suitability for service in sodium shall include consideration of changes in composition and properties of materials because of such factors as high temperature, mass transfer, carburization, and decarburization. Welding ends (nozzles) of the valves shall be compositionally and dimensionally compatible for welding purposes with the austenitic stainless steel pipe elements to which they connect.

3. Reliability and Quality Assurance

3.1 Reliability

3.1.1 Critical Parts Identification

3.1.2 Failure History

3.1.3 Design Alternatives Evaluation

3.1.4 Failure Mode and Effects Analysis

3.1.5 Design Review

3.2 Quality Assurance

3.2.1 Identify quality problems

3.2.2 Translation of Quality Criteria into Engineering Documentation

- 3.2.3 Documentation release and change control
- 3.2.4 Research work documentation
- 3.2.5 Quality Assurance requirements in procurement documents
- 3.2.6 Supplier quality performance evaluation
- 3.2.7 Materials and parts identification and traceability
- 3.2.8 Process controls
- 3.2.9 Inspections and tests to insure conformance to design

requirements.

- 3.2.10 Measuring instruments calibration control
- 3.2.11 Handling and storage damage control
- 3.2.12 Discrepancy and failure reports and cause and corrective

action analysis.

4. Performance Requirements

4.1 Functional requirements

a. Check (anti-backflow) valves shall be capable of preventing reversal of normal flow. Valve design shall provide for valve to open sufficiently to allow approximately 1.5% of design flow at a differential pressure of approximately 1 psi to permit removal of reactor decay heat by natural convection of low-flow emergency means. Valve design shall include "non-slam" features (dash-pot or other means to permit setting valve closure time from full open to full closed position in the range of 5 to 10 seconds) which reduce impact sufficiently to prevent generation of excessive inertial loads (fluid hammer) in the piping system and assure that no damage to the internal parts of the valve will result from repeated closures under operating conditions.

- b. Cracking and reseal pressures.
- c. In service functional tests during system checkout

4.2 Flow Requirements

- a. Line size range required
- b. Steady state and transient system requirements
- c. Flow vs gate position curve
- d. Full open ΔP at 120% design flow should be minimized for

system efficiency.

- e. Fluid velocity in pipe
 - 1) Design ——— 30 ft/sec
 - 2) Operating Range —10-40 ft/sec
- f. Hydraulic Hammer Limit

Hydraulic hammer shall be within limit. Each design should be analyzed to determine the interaction between the valve and the system.

This analysis should consider the effects of:

- 1) Valve closing time
 - 2) Upstream system geometry
 - 3) Fluid velocity
 - 4) Valve flow characteristic
- g. Vibration Limit

Flow through the valve shall not cause vibration which could result in malfunction of the valve or other components in the system.

4.3 Leakage Requirements

4.3.1 Internal leakage

a. Maximum LNa leakage at 1210°F design and over 250°F to 1200°F operating temperature.

b. Equivalent ambient water and/or gas leak rates for a. above.

c. Allowable increase in leakage as a function of LNa exposure time.

d. Effect of cycling on leakage rate.

e. Method and fluids to be used for measuring leakage.

f. Equipment required to test.

4.3.2 External leakage

a. Allowable LNa leakage

1) With external exposure to air.

2) With external exposure to LNa

b. Equivalent ambient inert gas leak rates for a. above.

c. Method and fluid to be used to measure leakage at:

1) Separable and/or welded joints

2) Component porosity

d. Equipment required to test.

4.4 Pressure rating requirements (per ASME B 16.5)

4.4.1 At operating temperatures

Nominal working

Maximum working

Design

Leak

Proof

Burst

NOTE: Valves shall be designed to withstand the above pressures using the 1% creep strength, of the material used, (5000 lb/in² for CRES 316 body material) at 100,000 hr < t ≤ 30 yr if t ≥ 30 yr data is not available.

4.4.2 At ambient temperature

Nominal working

Maximum working

Design

Leak

Proof

Burst

4.4.3 External pressure

a. Leak testing (10⁻⁶ mm Hg internal and atmospheric external).

b. Submerged in LNa pool

4.5 Temperature Requirements

a. Design

b. Operating temperature range 1210°F 250° - 1200°F.

c. Operating temperature transients

Initial Temperature	Cycles		Diff. Between Initial & Final Na Temperature
1200°F	300 cycles	at -20°F/sec for 15 sec	300°F
	25 cycles	at -30°F/sec for 10 sec	300
800°F	300 cycles	at -10°F/sec for 30 sec	300
	25 cycles	at +30°F/sec for 10 sec	300

d. External environment temperature

- 1) +150°F air or inert gas
- 2) LNa at valve operating temperature of 250°F to 900°F

e. Preheating

Prior to reactor startup heat transport system valves in an air or gas shall be preheated, by integral (external or internal to the valve, as required) heaters, to 400°F maximum at a rate of 50°F/hr. (See also paragraph 5.5.2.2 Auxiliary Equipment, Preheaters)

f. Functional Requirements at temperature

1) Valves shall be capable of performing their shutoff and/or flow control function at any temperature between 250 and 1200°F, and while temperature is changing at a rate not exceeding 100°F/hr in this temperature range. A valve shut at any temperature between 250 and 1200°F shall have the capability of being opened at any other temperature between 250°F and 1200°F.

4.6 Plant operating cycles, normal

a. Startup and shutdown (number) 500

- 1) Cyclic pressure range (psi) 200
- 2) Rate of pressure change (maximum psi/sec) 20
- 3) Cyclic temperature range (°F) 250 to 1200
- 4) Rate of temperature change (maximum °F/hr) 100

b. Load following (number) 20,000

- 1) Cyclic pressure range (psi) 200
- 2) Rate of pressure change (maximum psi/sec) 20

5. Design Requirements

5.1 Structural Requirements:

- a. Definition of design factor (or safety factor) and on what mechanical property (e.g., S_{ty} or S_{tu}) based.
- b. Design factor values to be used for design based on
 - 1) 1200°F creep
 - 2) 1200°F short term loading
 - 3) 150° extended term loading
 - 4) 150° short term loading
- c. Welding ends (nozzles) of the valves and transitions thereto shall be proportioned to minimize differential dimensional response between pipe elements and valve body to thermal transients.
- d. Valve supports shall be provided that will accommodate translational movements of the valve and growth due to thermal expansion of the valve body, bonnet, stem, and appurtenances.

5.2 Endurance Requirements

5.2.1 Service Life

- a. Design accumulative service life - 30 years
- b. Typical (or estimated) service life mode vs time curve, i.e., are there any loop or reactor shutdowns planned during the valve's service life. (See also 4.6, plant Operating Cycles, Normal)
- c. Effects of component erosion on service life.

5.2.2 Cycle Life

- a. Under operating conditions (see also 4.65, Plant Operating Cycles, Normal).
- b. Qual testing cycles
- c. Total (fabrication, testing, service)
- d. Effect of cycles on wearing of valve components.

5.3 Operating Fluid

- a. Sodium composition
- b. Physical properties (density, viscosity, etc., as a function of temperature).
- c. Allowable contaminant particle size.
- d. Contaminant sources and possible composition.
- e. Oxygen content.

5.4 Special Requirements

- a. Design must prevent or compensate for sodium oxide buildup on moving parts. This is especially critical at the hinge on check valve gate.
- b. Valve orientation in system.
 - 1) Effect on gate operation (gravitational) at shutoff and convection cooling position of gate.
 - 2) Effect on drainage of the valve.

5.5 Facility Requirements

- a. Based on valve and operator needs (power and controls).
- b. Imposed on valve (space and orientation limits).

5.5.1 Interface Requirements

a. Valve

- 1) Line size range vs valve type.
- 2) Valve type and size vs weight.

b. Valve-to-line interface

- 1) Joint design
- 2) Maximum (transient and steady state) axial and

bending loads imposed on the valve by the line and deflections if deflection is a governing factor.

- 3) Vibration
 - 4) Shock (system and seismic?)
-

c. Valve-to-facility interface

- 1) **Location** of valve in system.
- 2) Orientation of valve to system (vertical,

horizontal, etc.).

3) Space envelope of valve as a function of line size and valve type.

d. Radiation

- 1) Types and rates from fluid and external sources.

5.5.2 Auxiliary Equipment

5.5.2.1 Instrumentation

5.5.2.1.1 Monitoring

- a. Monitoring requirements and methods for check valve (body strain and creep, temperature, pressure, etc.).
- b. Energy requirements and source.
- c. Monitoring readout requirements.
- d. Connector interfaces.

5.5.2.2 Preheaters

- a. Performance requirements (see also paragraph 4.5, Temperature Requirements).
- b. Power requirements
- c. Interface requirements
 - 1) Connectors
 - 2) Mounting

5.5.2.3 Fluid Systems

5.5.2.3.1 Cooling Fluid

- a. Type and properties
- b. Source
- c. Temperature
- d. Pressure and flow required and/or available.
- e. Connector interfaces

5.5.3 Installation Requirements

- a. Provision shall be made for handling and supporting the valve during installation into the system.

b. Support, if required, shall be provided for the valve during service. (Lines may move relative to facility structure due to thermal expansion.)

c. Remote handling: if required, the valve shall be designed for remote handling and maintenance. Some of the problems associated with remote handling are:

- 1) Location of valve under nontransparent sodium pool.
- 2) Disassembly of valve after it is located.
- 3) Reassembly valve under Na pool.
- 4) Proximity of a radioactive source.

d. Inspection requirements - Inspection techniques and accept/reject criteria for inspection of valve prior to, during and after installation shall be formulated during the design phase. This includes acceptance testing and nondestructive quality assurance testing (i.e., X-ray of welds, etc.).

5.6 Shipping, handling and storage

- a. Temperature
- b. Shock
- c. Storage life
- d. Storage and packaging methods.

5.7 Maintenance

- a. Valve shall be designed for ease of maintenance.
- b. Valves to be submerged in a Na pool shall be designed so as to be serviceable without draining the Na pool.
- c. Valves shall be self-draining, i.e., trap a minimum of Na within the valve when the cooling loop is drained.

d. Seat-Seal designs shall consider effects of fluid contamination.

e. Provision should be made in the design of "freeze seal" shaft seals for the removing of Na oxides, preferably without disassembly of the valve.

f. Practicality and methods for valve rework, e.g., seal-seat rework.

g. Cleaning methods (prior to, during and after installations) and cleaning agents to be used shall be specified.

h. Interchangeability: consideration shall be given to the following:

- 1) Valve-to-valve interchangeability
- 2) Component interchangeability
- 3) Component commonality, i.e., use of the same component

in different size valves.

5.8 Producibility

- a. Economical size limitations vs valve size and type.
- b. Preferred fabrication techniques vs valve size and type.
- c. Relative cost vs valve type and size

5.9 Problem Areas

- a. Valve stem seals
- b. Sodium oxide accumulation in
 - 1) Freeze seals
 - 2) Between moving parts

- c. Thermal stresses, creep and distortion.
- d. Shutoff sealing (seat geometry, distortion, leakage properties of Na, etc.
- e. Self-welding and galling.