UK EPR	Title: PCSR – Sub-chapter 6.8 – Main steam relief train system - VDA [MSRT]
	UKEPR-0002-068 Issue 04

Total number of pages: 16	Page No.: I / III
Chapter Pilot: M. LACHAISE *Name/Initials* [signature] *Date 25-06-2012*	
Approved for EDF by: A. PETIT *Name/Initials* [signature] *Date 26-06-2012*	Approved for AREVA by: G. CRAIG *Name/Initials* [signature] *Date 26-06-2012*

REVISION HISTORY

Issue	Description	Date
00	First issue for INSA information	11-12-2007
01	Integration of technical and co-applicant comments	28-04-2008
02	PCSR June 2009 Update: – Clarification of text – Technical update according to December 2008 design freeze	26-06-2009
03	Consolidated Step 4 PCSR update: - Minor editorial changes - Update of references (English translations)	30-03-2011
04	Consolidated PCSR update: - References listed under each numbered section or sub-section heading numbered [Ref-1], [Ref-2], [Ref-3], etc - Minor editorial and typographical changes	26-06-2012

For information address:

AREVA NP SAS
Tour AREVA
92084 Paris La Défense Cedex
France

EDF
Division Ingénierie Nucléaire
Centre National d'Equipement Nucléaire
165-173, avenue Pierre Brossolette
BP900
92542 Montrouge
France

TABLE OF CONTENTS

SUB-CHAPTER 6.8 – MAIN STEAM RELIEF TRAIN SYSTEM - VDA [MSRT] [REF-1] TO [REF-5]

0. SAFETY REQUIREMENTS

0.1. SAFETY FUNCTIONS

0.1.1. Reactivity control

The Main Steam Relief Train system VDA [MSRT] does not contribute to controlling reactivity.

0.1.2. Decay heat removal

The VDA [MSRT] must be capable of removing decay heat by dumping steam from the main steam system to atmosphere (in the period between hot shutdown and connection of the RIS/RRA [SIS/RHRS]) in the event of a turbine trip with the condenser unavailable.

During PCC-2 to PCC-4 or RRC-A events, the VDA [MSRT] must remove decay heat by discharging steam to the atmosphere in order to achieve a safe shutdown state (connection of the RIS/RRA [SIS/RHRS]).

During small or intermediate breaks in the primary cooling system, or in the event of Steam Generator Tube Rupture (SGTR), the VDA [MSRT] system may be used to cool the primary cooling system until the MHSI injection pressure is reached (partial cooling).

Note: The latter two functions may be provided by steam dump to the condenser if it is available, but, for classification reasons, this possibility is not considered in the corresponding PCC-2 to PCC-4 studies.

During small or intermediate breaks in the primary cooling system combined with the total failure of the MHSI and when steam dump to the condenser is not available, the VDA [MSRT] may be used to cool the primary cooling system until the LHSI injection pressure is reached (rapid cooling).

0.1.3. Containment of radioactive substances

During PCC-2 to PCC-4 and RRC events, the VDA [MSRT] contributes to protecting the steam generator against overpressure.

0.2. FUNCTIONAL CRITERIA

0.2.1. Reactivity Control

The VDA [MSRT] does not contribute to the control of reactivity.

0.2.2. Decay heat removal

The VDA [MSRT] is designed to remove decay heat to ensure that the fuel temperature remains below the associated safety limits and the reactor coolant pressure boundary (RCPB) remains within its design conditions.

Decay heat must be removed during PCC-2 to PCC-4 events even assuming loss of external power supplies combined with a single failure (one VDA [MSRT] train fails to operate).

0.2.3. Containment of radioactive substances

The VDA [MSRT] contributes to protection against overpressure (see Sub-chapter 3.4).

0.3. DESIGN REQUIREMENTS

0.3.1. Requirements from safety classifications

Safety classification

The VDA [MSRT] is safety classified according to the classification presented in Sub-chapter 3.2.

Single failure criterion (active and passive)

For components providing F1 functions, the single failure criterion must be satisfied in order to ensure adequate redundancy.

Emergency power supplies

The power supply for components with an F1 function must be backed-up so that their functions can be performed even in the event of loss of external power.

Qualification for operating conditions

Components providing an F1 function must be qualified for the ambient conditions anticipated when they are required to operate in order to perform their safety function.

The resulting requirements for the component design (integrity, operability, functional capacity, etc.) are presented in Sub-chapter 3.6.

Mechanical, electrical, instrumentation and control classifications

The classifications are presented in Sub-chapter 3.2.

Seismic classification

The VDA [MSRT] must be seismically classified according to the classification rules presented in Sub-chapter 3.2.

Periodic tests

VDA [MSRT] safety classified components must be tested periodically.

0.3.2. Other statutory requirements

0.3.2.1. Basic Safety Rules

See Sub-chapter 1.4.

0.3.2.2. Technical guidelines

See Sub-chapter 3.1.

0.3.3. Hazards

Internal hazards

The VDA [MSRT] must be protected against internal hazards in accordance with the requirements presented in Sub-chapter 13.2.

The break exclusion concept applies to the main steam lines inside containment (between the SG outlet and the containment penetration fixed point) and outside containment (between the containment penetration and the first fixed point downstream of the main steam isolation valve), including the connections to the three largest connected lines, (i.e. the VDA [MSRT] line up to the isolation valve and the two VVP [MSSS] safety relief valve connections).

External hazards

The VDA [MSRT] must be protected against external hazards in accordance with the requirements presented in Sub-chapter 13.1.

0.4. TESTS

Preliminary tests

Preliminary commissioning tests are required to enable the adequacy of the VDA [MSRT] design and performance to be ensured.

Periodic tests and in-service inspection

The location and design of the VDA [MSRT] equipment must allow accessibility for in-service inspection and periodic testing. The safety classified components must be tested and checked for functionality.

1. SYSTEM ROLE

The VDA [MSRT] consists of pipework and power-operated valves that discharge steam from the secondary cooling system into the atmosphere.

Apart from the safety functions described in § 0, the VDA [MSRT] is designed to perform the following functions:

- The system forms part of the main secondary cooling system. It (partially) protects the steam generator against overpressure.
- The system is used for dumping heat from the steam generators to the atmosphere when the condenser is unavailable. In particular, it may be used to cool the reactor between the hot shutdown state and LHSI connection conditions in RRA [RHRS] mode.

2. DESIGN BASIS

2.1. GENERAL ASSUMPTIONS

The system design basis is described in Sub-chapter 10.3 dedicated to VVP [MSSS].

The system design provides protection against overpressure. Specifically the opening pressures of the VDA [MSRT] atmospheric relief valves and the VVP [MSSS] safety relief valves are as follows:

- Total shut-off head of the MHSI pumps is below the opening pressure of the VDA [MSRT] atmospheric relief valves, which is in turn below the set-pressure of the VVP [MSSS] safety relief valves.
- The capacity of a VDA [MSRT] train is 50% of the full load steam production at the design pressure [Ref-3].
- A high level of leak-tightness is required for control valves that are required to protect against failure to close the corresponding isolation valves.

The following design requirements also apply:

- The VDA [MSRT] control valves and isolation valves must be capable of discharging sub-cooled water or a steam/water mixture in the event of SG overfill, or following a 2A-MSLB.
- Silencers are designed such that the noise from a steam discharge through the VDA [MSRT] remains within statutory limits.

2.2. INSTRUMENTATION AND CONTROL

2.2.1. General design

In each train the following components are powered and controlled by the Instrumentation and Control equipment:

- The solenoid pilots of isolation valve (the opening/closing function is controlled by different electrical divisions but powered with DC power supply from the electrical division corresponding to the mechanical division containing the valve).
- The control valve motor (powered by a non-interruptible AC power supply from the electrical division corresponding to the mechanical division containing the valve).

2.2.2. Automatic control

For PCC-2 to PCC-4 events automatic control of the VDA [MSRT] relief valves is achieved by the safety classified Programmable Logic Control (PLC) system.

The automatic control actions are:

- Opening of valves to achieve and maintain a controlled constant steam pressure when a high steam pressure exists.
- Partial cooling controlled at 250°C/h when there is a low pressuriser pressure (due to a small primary break).
- Partial cooling controlled at 250°C/h when there is a high water level in a steam generator (due to SGTR). (For the cooling, the isolation valve which is closed in normal operation is opened, and the control valve which is open in normal operation is used to control the main steam pressure).
- Generation of an isolation signal when there is low steam pressure (discharge to atmosphere due to inadvertent valve opening).
- Generation of an isolation signal when a high SG water level exists (due to SGTR) and partial cooling has been completed.

2.2.3. Controls that are accessible to the operator

- Control valve actuation: the VDA [MSRT] control valves are controlled (PICS and SICS) from the Main Control Room (MCR).
- Isolation valve actuation: all the solenoid pilot valves may be individually actuated from the Main Control Room (MCR) by PICS and SICS (to actuate the isolation valves or to carry out tests).

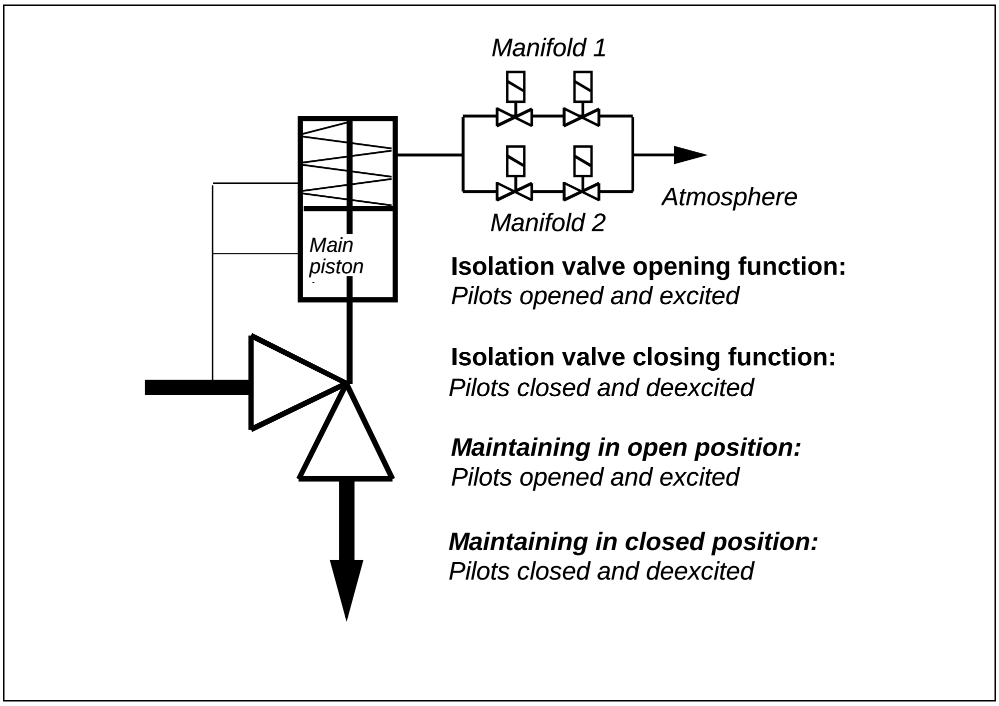
3. EQUIPMENT DESCRIPTION AND CHARACTERISTICS [REF-2]

3.1. DESCRIPTION OF THE ISOLATION VALVES

The VDA [MSRT] isolation valve is located in the main steam line between the containment penetration and the main steam isolation valve (MSIV). It is a wedge type globe valve with a self-controlled relief valve using the depressurisation principle. A hold-open device is mounted on the valve envelope.

A set of steam pilot valves is used for opening and for closing. This set consists of four solenoid pilot valves with two pilots in series in each of the two redundant control lines. This configuration is used to prevent a pilot valve failure from causing inadvertent opening, or prevention of opening, of the isolation valve.

After opening, the valve remains opened even in case of I&C power default and until a closing order is emitted. When the steam pressure is too low, the valve is operated from a local source of compressed air.



3.2. DESCRIPTION OF CONTROL VALVE

The VDA [MSRT] control valve is a power-operated wedge type globe valve welded into the relief line downstream of the VDA [MSRT] isolation valve.

3.3. FLOW DIAGRAM

A simplified flow diagram [Ref-4] for the VDA [MSRT] is given in Sub-chapter 6.8 - Figure 1.

4. OPERATING CONDITIONS

4.1. SYSTEM NORMAL OPERATING STATE

During power operation, the VDA [MSRT] isolation valves are closed and the control valves are open. This allows a faster system reaction to be achieved in the event of secondary side over-pressurisation, because the isolation valve opening time is shorter than the control valve opening time.

4.2. SYSTEM OPERATING CONDITIONS

- When the reactor is in hot standby and the condenser is not available, the steam generated in the steam generators is discharged to atmosphere.
- During PCC-2 to PCC-4 events, the VDA [MSRT] controls the secondary pressure until the controlled stated is obtained.
- During PCC-2 events, anticipating condenser unavailability, steam is discharged to the atmosphere which enables LHSI connection conditions to be established in RRA [RHRS] mode. The rate of cooling is monitored.
- During PCC-3 or PCC-4 accidents (anticipating condenser unavailability), when depressurisation is required to reach MHSI injection conditions, the partial cooling procedure is initiated to cool the system at 250°C/hr and thus depressurise the primary cooling system.
- During PCC-3 or PCC-4 accidents (anticipating condenser unavailability), the VDA [MSRT] is used to establish LHSI connection conditions in RRA [RHRS] mode at 180°C to allow decay heat removal.

4.3. SYSTEM TRANSIENT STATES

Transient states involving opening of VDA [MSRT] isolation valves are given in section 4.2.

5. PRELIMINARY SAFETY ANALYSIS

5.1. COMPLIANCE WITH REGULATIONS

See Sub-chapter 1.4

5.2. COMPLIANCE WITH FUNCTIONAL CRITERIA

The VDA [MSRT] is designed to remove decay heat to ensure that the fuel temperature remains below safety limits and the primary cooling system remains within its design conditions.

The VDA [MSRT] is designed to ensure that the pressure in the steam generators does not exceed certain limits during PCC-2 to PCC-4 events and RRC accidents. Compliance with the pressure limits is discussed in section 1 of Sub-chapter 3.4.

5.3. COMPLIANCE WITH DESIGN REQUIREMENTS

5.3.1. Safety classification

Compliance of the design, construction, materials and equipment with the requirements of the classification rules is described in detail in Sub-Chapter 3.2.

5.3.2. Single Failure Criterion

See Sub-chapter 6.8 - Table 1.

5.3.3. Qualification

The equipment is qualified in accordance with the requirements of Sub-chapter 3.4.

5.3.4. Instrumentation and control

Compliance of the design and construction of instrumentation and control equipment with the requirements of the classification rules is described in Sub-chapter 3.2.

5.3.5. Emergency power supplies

Following total loss of external electrical power supplies (LOOP), the VDA [MSRT] trains are backed up by the main diesel generator sets.

In the event of a SBO [station blackout] event, VDA [MSRT] trains 1 and 4 are backed up by the emergency plant cooldown diesel generator sets.

5.3.6. Hazards

The following tables summarise the hazards taken into account in the VDA [MSRT] design

Internal hazards	Protection required in principle	General protection	Specific protection introduced in the system design
Pipe breaks	Yes, no more than one train affected	Separating the trains	Break preclusion concept
Tank, pump and valve breaks	Yes, no more than one train affected	Separating the trains	-
Internal missiles	Yes, no more than one train affected	Separating the trains (a single train affected)	-
Dropped load	Yes, no more than one train affected	Exclusion via the handling equipment design	-
Internal explosion	Yes, no more than one train affected	Separating the trains	-
Fire	Yes, no more than one train affected	Separating the trains	-
Internal flooding	Yes, no more than one train affected	Compartmentalisation	-

External hazards	Protection required in principle	General protection	Specific protection introduced in the system design
Earthquake	Yes	Location in two Safeguard Buildings	Seismic design
Aircraft crash	Yes	Location in two Safeguard Buildings	Geographical separation of the train into two pairs Resistance to vibrations
External explosion	Yes	Location in two Safeguard Buildings	Design of compartment for the VVP [MSSS]
External flooding	Yes	Location in two Safeguard Buildings	-
Snow and wind	Yes	Location in two Safeguard Buildings	-
Extreme cold	Yes	Location in two Safeguard Buildings	-
Electromagnetic interferences	Yes	Location in two Safeguard Buildings	-

6. TESTS, INSPECTION AND MAINTENANCE

The VDA [MSRT] safety classified components are subject to periodic testing.

The functions to be tested are identified from accident studies. For each safety function the success criteria defined are the same as those assumed in the accident studies.

The testing periodicity of all of the functions to be tested is justified by specific studies.

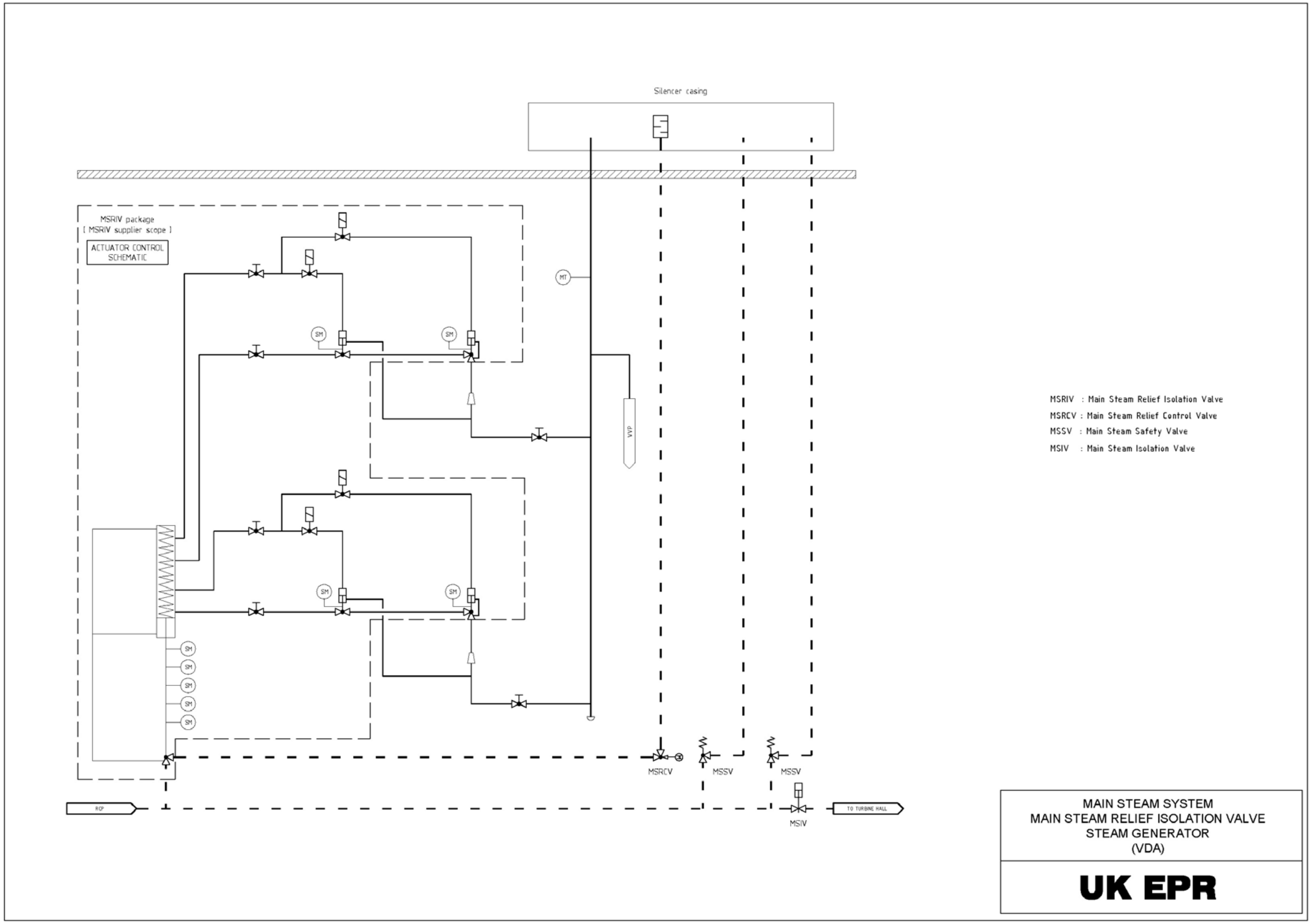
The in-service inspection programme will be defined during the EPR detailed design phase. For each inspection area, it will be confirmed that there is adequate accessibility. In addition, it will be confirmed that the non-destructive test requirements are compatible with the component design and manufacture (surface finish, geometry, etc.). In addition, for any factory weld for which an inspection is planned, non-destructive tests will be carried out to provide an "initial inspection" status

Periodic tests and Preventive Maintenance Programmes will be defined during the EPR detailed design phase.

SUB-CHAPTER 6.8 - TABLE 1: CONSEQUENCES OF SINGLE FAILURE

Component	Function	Single failure	Explanation
Control valves	Decay heat removal or cooling	Opening fault	Redundancy depends on the other VDA [MSRT] train
	SG depressurisation	Opening fault	Function is only required over the long-term. The redundancy depends on opening the conditioning line corresponding to the affected SG.
	Shutdown of the activity discharge during SGTR	Closing fault	Redundancy depends on the affected SG isolation valve.
Isolation valves	Decay heat removal or partial cooling	Opening fault for any solenoid pilot valve	No effect on the function due to the solenoid pilot valve configuration.
		Main valve opening fault	Redundancy depends on the other VDA [MSRT] (SG)
	Isolated SG depressurisation	Opening fault for any solenoid pilot valve	No effect on the function due to the solenoid pilot valve configuration.
		Main valve opening fault	Function is only required over the long-term. The redundancy depends on opening the conditioning line corresponding to the affected SG.
	Shutdown of the activity discharge during SGTR	Main valve closing fault	Redundancy depends on the affected SG control valve.

SUB-CHAPTER 6.8 - FIGURE 1: VDA [MSRT] SIMPLIFIED FLOW DIAGRAM



SUB-CHAPTER 6.8 – REFERENCES

External references are identified within this sub-chapter by the text [Ref-1], [Ref-2], etc at the appropriate point within the sub-chapter. These references are listed here under the heading of the section or sub-section in which they are quoted.

The following references are used throughout this sub-chapter:

[Ref-1] System Design Manual – Atmospheric Steam Dump System (VDA [MSRT]) - P1. NESS-F DC 624 Revision A. AREVA. December 2009. (E)

[Ref-2] System Design Manual - Main Steam Relief Train - Part 2: System Operation, NESS-F DC 580 Revision A. AREVA. November 2009. (E)

[Ref-3] System Design Manual - Main Steam Relief Train - Part 3: System Design. NESS-F DC 581 Revision A. AREVA. November 2009. (E)

[Ref-4] System Design Manual - Main Steam Relief Train - Part 4: Flow diagrams. NESS-F DC 595 Revision A. AREVA. September 2009. (E)

[Ref-5] System Design Manual – Atmospheric Steam Dump System (VDA [MSRT]) P5 – Instrumentation & Control. NESS-F DC 630 Revision A. AREVA. December 2009. (E)