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IN SERVICE INSPECTION OF SUPERPHENIX 1 VESSELS :MIR

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We present the in-service inspection device, MIR, which has been specially developed for the visual and ultrasonic examination of SUPERPHENIX 1 vessels.

INTRODUCTION

Although no in-service inspection constraints were imposed on the Phenix vessels, the Safety Authorities asked that the design of SuperPhenix 1 makes it possible to monitor throughout the lifetime of the reactor, surface and internal defects on the main vessel. A pool design and the presence of heat baffles inside the main vessel make access from the inside of the vessel impossible.Thus, an inspection can only be performed from the outside of the main vessel: the distance betweeen the walls of the main and safety vessels is such that an inspection device can be introduced into the corresponding space. As the design of the reactor precludes radiographic inspection, the method which was selected for monitoring internal defects in the main vessel is ultrasonics. However, the anisotropic structure of austenitic stainless steel welds limits the performance of this technique.

OPERATING CONDITIONS

The inspections will take place during fuel handling operations when the temperature of the main vessel is 180°C and that of the safety vessel 120°C. Both vessels are made of stainless steel plates, 25 to 60 mm thick for the main vessel and 25 to 30 mm thick for the safety vessel. They are suspended from the slab (figure 1) which is provided with 12 oval shaped holes (440 x 700 mm).

Thus, the inspection device must first go across the slab and the thermal barrier at the upper part of the vessels, through an oval shape hole and then expand to the distance between the vessels which varies from 620 to 700 mm.

DESCRIPTION OF MIR

The inspection device, MIR (Module d'Inspection des réacteurs Rapides)consists of :
- a four-wheel drive vehicle provided with inspection equipement,

- a winch and penetration shaft extending from the thermal barrier up to a level several meters higher than the slab,
- a composite cable for the electrical and fluid supplies,and a steel cable,
- a computer assisted control system.

Most of the design criteria adopted have resulted out of safety considerations. It must be possible to extract the vehicle, even under emergency conditions. As it is not possible to permanently install a rail system even over the surface of the safety vessel, the inspection device must be able to move autonomously and to identify and track the welds on the vessels. It is necessary that all the materials used to construct the inspection device or to operate in conjunction with it must be compatible with the reactor.

The vehicle consists of a central structure about which four arms are articulated, two longitudinal arms and two side arms (figure 2), at the end of which are fitted four traction and rotation wheels, two of them resting on each vessel.

The spreading-out and folding back function and the suspension function are independantly actuated by gas jacks. In case of emergency, the vehicle can be folded back by a controlled traction on a steel cable.

Guidance of the vehicle along the welds is achieved by eddy-current devices described elsewhere [1]. The safety vessel is provided with a large number of reference marks which are engraved on its walls and coded. These marks are aligned with the projections of the welded seams of the main vessel on the safety vessel and with the welded seams of the safety vessel itself. The distance between two consecutive marks along a weld is about 0.5m. A total of about 12,000 characters were punched (with a ball punch) onto the walls.

The non destructive examination equipment (figure 2) enables visual and ultrasonic examination to be performed.

A television camera housed in an insulated enclosure cooled by a nitrogen gas flux is used for visual examination purposes. A prism enables the camera to "see" both vessels at the same time : the marks engraved on the safety vessel are associated with the image of the weld on the main vessel. In this way a reference is obtained for the position of the device in the intervessel space. The camera is fitted with a 2/3" vidicon tube allowing a standard 625 line definition.

Special high temperature focussed ultrasonic probes have been developped for this inspection [2]. These probes are located in a special enclosure fitted with a gasket allowing immersion technique examination. A scanning motion parallel to the longitudinal axis of the device is given to the probes. The combination of this motion and the transverse progression of the vehicle enables the entire examination of the welded joints. 45° and 70° longitudinal waves are used for butt welds examination, while the core support structure weld of the main vessel is examined using 0° and 35° longitudinal waves. The acoustic coupling medium is a heavy benzene derivative, called GILOTHERM RD. Temperature tests have confirmed the compatibility of this liquid with the reactor. Its vapor pressure is such that it can be eliminated after control. The performance of these high temperature probes is summarized in figure 3.

The electrical and fluid supply is assembled in a composite cable : it includes and no less than 200 individual electrical connections two gas supplies, one for cooling down the TV camera,electrical motors..., the second one to actuate the gas jacks.

Because of the high density of components on the reactor slab, the cable winding winch is located some 6 meters above the slab level. It simultaneously ensures the winding and unwinding of both the emergency steel cable and the composite cable. A special design has made it possible to avoid the use of rotating electrical contacts.

The winch is supported by a penetration shaft which is seated on the slab and extends lower than the thermal barrier.

A large number of functions need to be simultaneously assured and monitored in real time: the elementary tasks are microprocessor-controlled while a micro-computer controls their chaining.

CONCLUSION

In order to perform the necessary inspection on the main vessel of SuperPhenix 1, a specific equipment was developed. Because of the design of the reactor, the inspection device, MIR, is a true robot. After being qualified through room temperature and high temperature tests on different mock-ups, MIR will be field operated for the first time during the first quarter of 1985.

[1] B.DAVID - M.PIGEON -
EDDY CURRENT GUIDANCE OF THE AUTOMATIC INSPECTION MACHINE FOR THE MAIN VESSEL OF THE SUPERPHENIX REACTOR
Communication at : 7th Conf. NDE GRENOBLE 1985

[2] C.GONDARD - M.ROULE -
IN-SERVICE INSPECTION FOR SUPERPHENIX VESSELS:
Development of ultrasonic techniques available at high temperature
Communication at : 6th Conf.on NDE ZURICH 1983

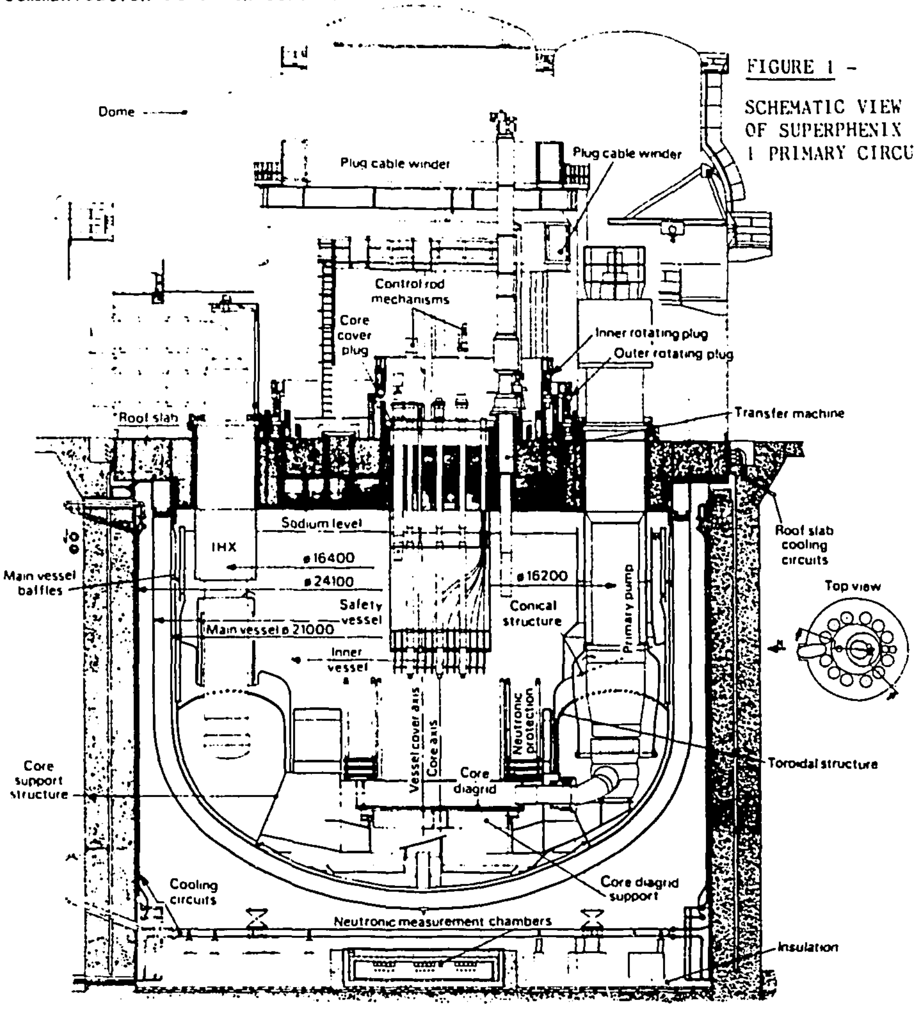

FIGURE 1 -
SCHEMATIC VIEW OF SUPERPHENIX 1 PRIMARY CIRCUIT

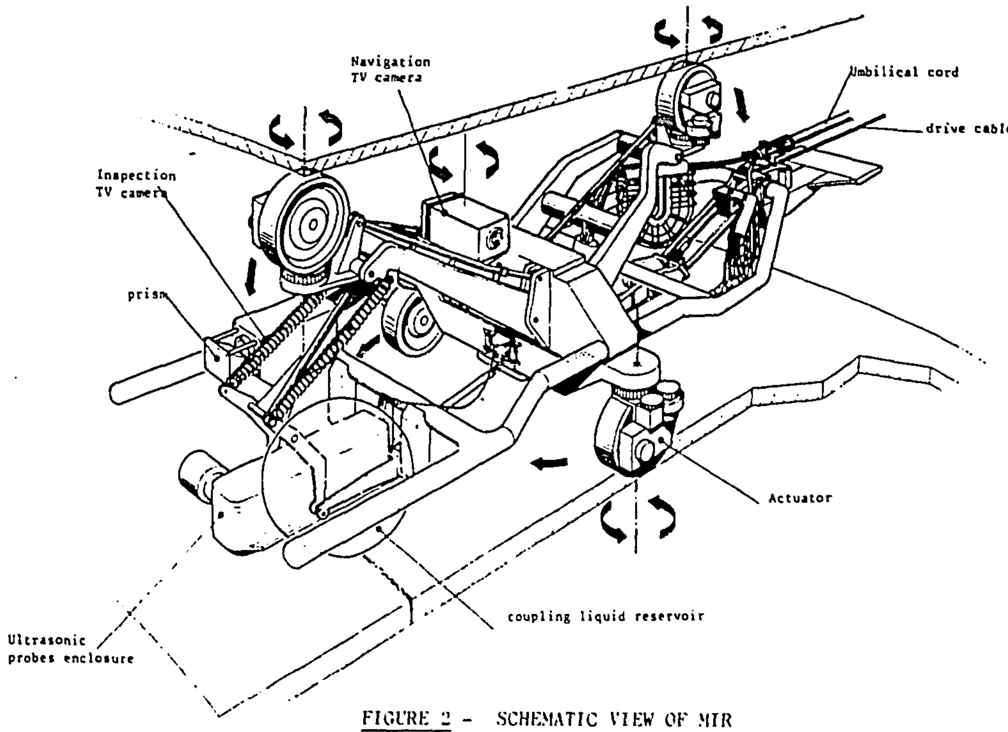

FIGURE 2 - SCHEMATIC VIEW OF MIR

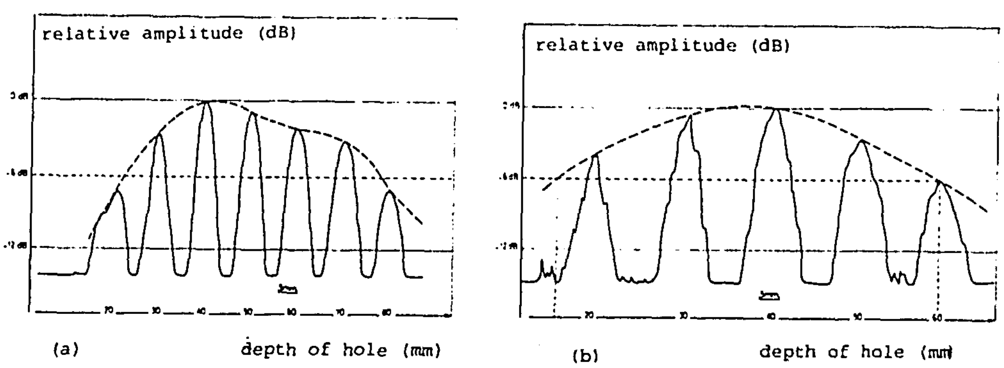

FIGURE 3 - AMPLITUDE VERSUS DEPTH CURVES FOR THE HIGH TEMPERATURE FOCUSSED PROBES :
a) longitudinal waves at 0°
b) longitudinal waves at 45°
c) longitudinal waves at 70°