Nuclear Engineering and Design 284 (2015) 300–307

Contents lists available at ScienceDirect

Nuclear Engineering and Design

journal homepage: www.elsevier.com/locate/nucengdes

An experience with in-service fabrication and inspection of austenitic stainless steel piping in high temperature sodium system

S. Ravi*, K. Laha, S. Sakthy, M.D. Mathew, A.K. Bhaduri

Mechanical Metallurgy Division, Indira Gandhi Centre for Atomic Research, Kalpakkam 603102, Tamil Nadu, India

HIGHLIGHTS

- Procedure for changing 304L SS pipe to 316L SS in sodium loop has been established.
- Hot leg made of 304L SS was isolated from existing cold leg made of 316LN SS.
- Innovative welding was used in joining the new 316L SS pipe with existing 316LN SS.
- The old components of 304L SS piping have been integrated with the new piping.

ARTICLE INFO

Article history:
Received 13 April 2014
Received in revised form
12 December 2014
Accepted 31 December 2014

ABSTRACT

A creep testing facility along with dynamic sodium loop was installed at Indira Gandhi Centre for Atomic Research, Kalpakkam, India to assess the creep behavior of fast reactor structural materials in flowing sodium. Type 304L austenitic stainless steel was used in the low cross section piping of hot-leg whereas 316LN austenitic stainless steel in the high cross section cold-leg of the sodium loop. The intended service life of the sodium loop was 10 years. The loop has performed successfully in the stipulated time period. To enhance its life time, it has been decided to replace the 304L piping with 316L piping in the hot-leg. There were more than 300 welding joints involved in the integration of cold-leg with the new 316L hot-leg. Continuous argon gas flow was maintained in the loop during welding to avoid contamination of sodium residue with air. Several innovative welding procedures have been adopted for joining the new hot-leg with the existing cold-leg in the presence of sodium residue adopting TIG welding technique. The joints were inspected for 100% X-ray radiography and qualified by performing tensile tests. The components used in the discarded hot-leg were retrieved, cleaned and integrated in the renovated loop. A method of cleaning component of sodium residue has been established. This paper highlights the in-service fabrication and inspection of the renovation.

1. Introduction

Liquid sodium has been chosen as the heat transfer medium in Fast Breeder Reactors (FBRs) because of its low melting point, high thermal conductivity, high heat capacity and of its retention as liquid over a wide range of temperatures because of its relatively low melting and high boiling points. In fast reactors, the components are in contact with flowing sodium at high temperature. Type 316L (N) austenitic stainless steel has been selected as main structural material for Proto-type Fast Breeder Reactor (PFBR) under construction at Kalpakkam, India (Mannan et al., 2003). At present, the designs of FBRs components are based on the creep and creep-fatigue interaction data generated in air environment. The effect of liquid sodium is expected to significantly alter the mechanical behavior such as creep, fatigue and creep-fatigue interaction especially in the presence of certain dissolved impurities (Ravi et al., 2012). It is essential to assess the environmental effects (sodium) on the mechanical properties of the steel, especially creep properties (Cook and Skeleton, 1974; Board and Brit, 1979; Horton, 1966; Natesan et al., 1972; Furukawa et al., 2009). A facility called in-sodium test (INSOT) has been established at IGCAR for mechanical testing of reactor and steam generator structural materials in flowing sodium.

A schematic view of the sodium loop of the mechanical testing facility is shown in Fig. 1. The sodium loop consists of dump tank, expansion tank, electro-magnetic pump (EMP), electro-magnetic (EM) flow meters, sodium to sodium heat exchanger, air cooler, test sections, bellow sealed globe valves, level probes, thermocouples, leak detectors and instrumentation control system. The loop has been broadly classified into hot-leg and cold-leg sections

* Corresponding author. Tel.: +91 44 27480500; fax: +91 44 27480075.
E-mail address: sravi@igcar.gov.in (S. Ravi).

http://dx.doi.org/10.1016/j.nucengdes.2014.12.034
0029-5493/

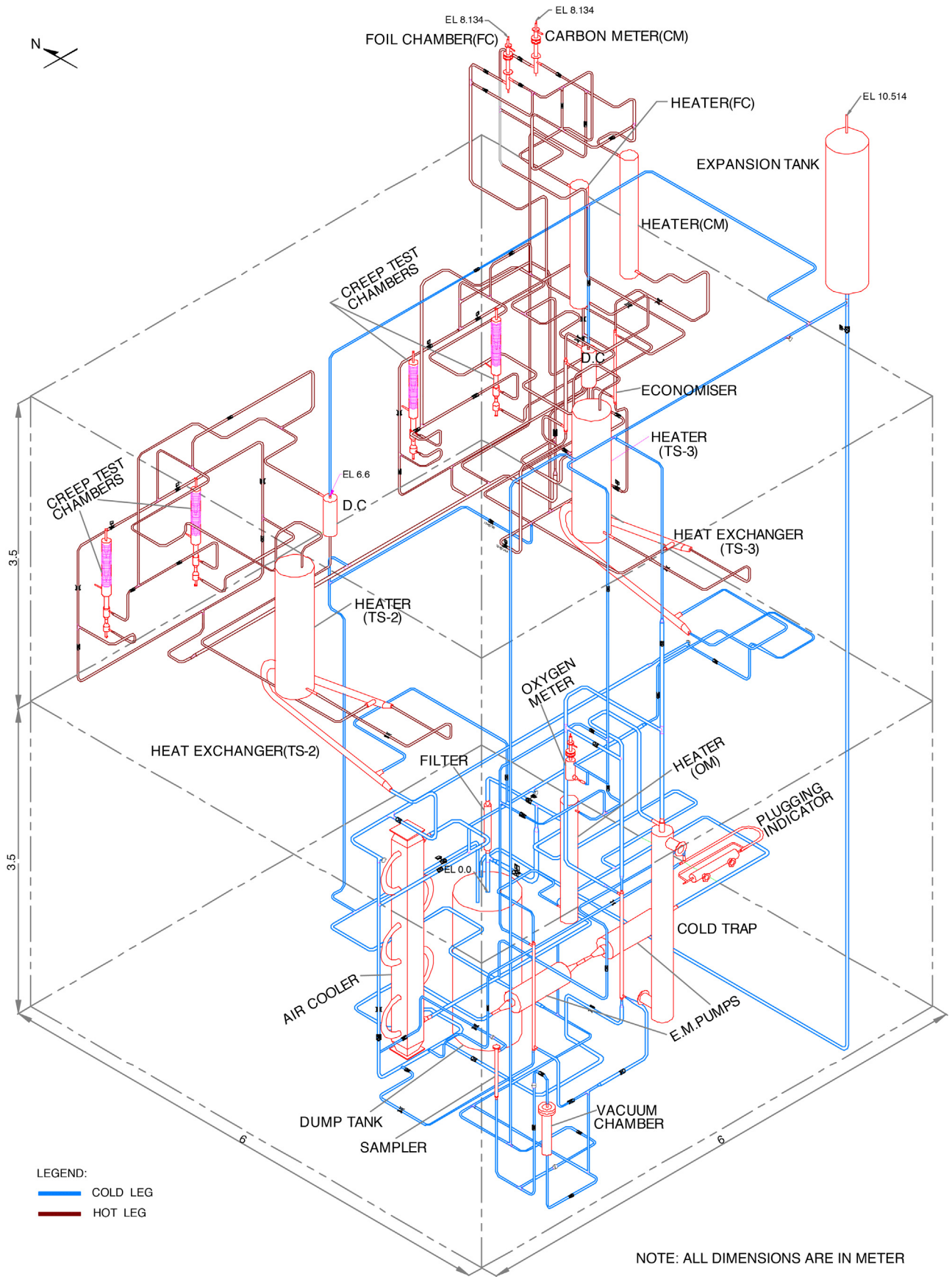

Fig. 1. General arrangements of INSOT facility.