

Removal of Sodium from the Component of the Sodium Purification Loop

Byung Ho Kim, Kyung Chai Jeong, Ji Young Jeong, Jong Man Kim, Byung Hae Choi, Ho Yun Nam
Korea Atomic Energy Research Institute, 150 Deokjin, Yuseong, Taejeon, Korea, 305-353, bhkim1@kaeri.re.kr

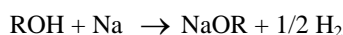
1. Introduction

The purpose of a cleaning process is to remove the residual sodium adhering to the component walls once it has been properly drained. It is necessary to clean and decontaminate a component, especially the large components of the primary coolant system; such as the intermediate heat exchangers and the primary pump. Improper and inadequate cleaning has in a number of cases resulted in problems in the storage, handling, and reuse of components [1,2]. Several types of failures due to improper cleaning procedures have been defined in the past. Inadequate and incomplete removal of sodium results in residues which may contain metallic sodium and alkaline compounds such as sodium hydroxide, sodium oxide, sodium carbonate, and various types of alcoholates. Reinsertion of components containing these compounds into a high-temperature sodium system can result in either the intergranular penetration characteristic of a high-oxygen sodium or an accelerated corrosion due to oxygen. The methods used for cleaning sodium equipment depend on the condition and types of equipment to be cleaned and whether the equipment is to be reused. Cleaning methods are needed that will avoid a deleterious local overheating, material surface degradation or deposits, chemical, physical, or mechanical damage, and external effects.

This paper discusses a steam-nitrogen gas cleaning method for the routine applications that permits the reuse of the cold trap in sodium.

2. Cleaning Techniques

With the exception of liquid ammonia and oil, all reagents used for sodium react chemically with the sodium. The reagents principally employed are water, steam, liquid ammonia, methyl alcohol, ethyl alcohol, and oil. Limited experience has been obtained using the higher alcohols and concentrated sodium hydroxide solutions. In principle, the reactions for water, steam, and alcohol can be represented by



where ROH is a reagent.



Several considerations result from the cleaning procedure. First, the reaction is exothermic. If the rate of the reaction exceeds the system heat losses, large temperature rises can be result. Second, the reaction liberates the hydrogen gas. Because hydrogen is flammable, it is presumed that the system has been designed to safely prevent a hydrogen–oxygen explosion. The third consideration stems from the possible insolubility of the sodium reactants in the solvent. If the reaction product tends to be insoluble in the reagent, a buffer layer is set up, thus preventing a complete reaction.

3. Experimental

3.1 Cleaning Apparatus

3.1.1 Dismantlement of Sodium Purification Loop

At KAERI, a sodium purification loop was designed and operated for the development of impurity measurement technology and a sodium purity control. On the completion of the experiments, the sodium purification loop was dismantled and the piping, components such as cold trap, plugging meter, electromagnetic pump, and valves etc. were taken out for sodium removal and cleaning. During the dismantling of the pipes, a large amount of sodium still resided in pipes (Figure 1). Sodium the pipes were cut into 2 to 4 meter lengths and cleaned by steam and water injection in air. Cold trap was dismantled and modified for a sodium cleaning in the cleaning apparatus as shown in Figure 2.



Figure 1. Sodium in pipes.

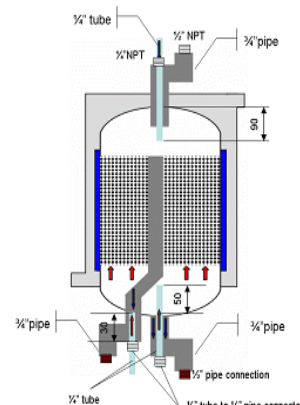


Figure 2. Cold trap to be cleaned.

3.1.2 Cleaning System

Superheated steam injection in a nitrogen gas atmosphere was adopted for the cold trap cleanup. Explosions were minimized by replacing any air in the cold trap with nitrogen gas. Figure 3 shows the P & I drawing of the sodium cleaning system. The sodium cleaning system consists of a steam supply system, nitrogen gas supply system, reactor (cold trap), gas release system, and data acquisition system etc.. Hydrogen which evolved in the cold trap was released to the air with a monitoring and controlling of the hydrogen concentrating in nitrogen gas. Most of the connecting pipe and tube is 1/2 inch in diameter. Gas flow rate of the steam and nitrogen, the pressure and temperature, the hydrogen concentration in the nitrogen gas, moisture content in nitrogen gas and the conductivity of the reactant were measured and controlled.

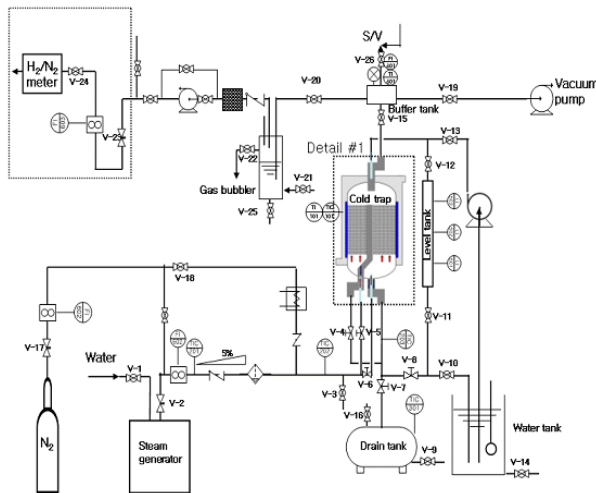


Figure 3. P & I drawing of sodium cleaning system.

3.1 Cleaning procedure

The first step of the sodium cleaning was to vacuum the cold trap and to fill the cold trap with nitrogen gas. The sodium in the cold trap was drained under the protection of nitrogen by a heating. The mixture of the steam-nitrogen under the protection of nitrogen was filled and the reaction rate was controlled by regulating the flow rate and the content of the vapor in the mixture. After the reaction was finished, water was filled from the effluent outlet. Nitrogen gas then started flowing to the cold trap with a 50 g/min, and it was kept almost constant. Initial steam flow rate was about 5g/min not to exceed the hydrogen concentration of 1% in the nitrogen gas.

4. Results

Figure 4 shows the hydrogen concentration change with the steam flow rate. During 120 hours after the initiation of steam injection, the hydrogen concentration greatly increased with the steam flow rate, up to a maximum, and then decreased to almost 0%. After stopping steam injection to the cold trap, the cold trap was filled with nitrogen gas again. Then water was filled for about 3 hours to clean sodium hydroxide from the cold trap's inner surface. During the filling of water into the cold trap, no hydrogen increase was observed.

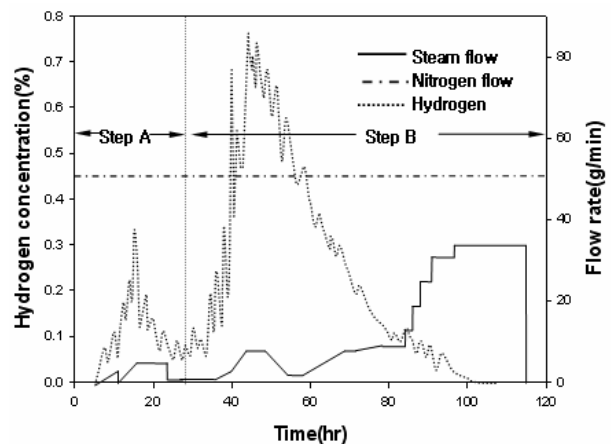


Figure 4. Typical curve of hydrogen content in nitrogen gas in cleaning apparatus.

5. Conclusions

The Study for removing the sodium from components of a sodium purification loop enabled KAERI to acquire valuable experiences in cleaning the components contaminated by sodium. The experiences acquired with this study will be applied to the project to clean contaminated components.

ACKNOWLEDGEMENT

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