

FINAL REPORT  
DEFICIENT 312 STAINLESS STEEL BUTTERING  
ON FLUED HEAD FITTINGS  
FOR PRIMARY CONTAINMENT PENETRATIONS  
AT  
LIMERICK GENERATING STATION  
UNITS 1 AND 2

PHILADELPHIA ELECTRIC COMPANY

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## 1.0 INTRODUCTION

- 1.1 The Limerick Project is using twelve forged, Grade 316 flued head fittings for primary containment piping penetrations which have the OD and ID of the weld end preparations buttered with Type 312 stainless steel. Cracks have been found in the Type 312 material.
- 1.2 Sargent Industries/Airite Division, El Segundo, California, is the supplier of the flued head fittings.
- 1.3 This report describes the nature and extent of the deficiency, and discusses the safety implications and corrective actions.

## 2.0 DESCRIPTION OF DEFICIENCY

### 2.1 Chronology

In February 1976 a review of the Core Spray and Low Pressure Coolant Injection (LPCI) systems was conducted. It was concluded that the flued head fittings for primary containment penetration for these systems, which had been fabricated of SA-182, Gr. 316 material, may be susceptible to intergranular stress corrosion cracking (IGSCC). To provide an increased margin against susceptibility to IGSCC it was decided to butter the OD and ID of the flued head weld end preparations with Type 312 stainless steel, followed by full solution heat treatment, as recommended by the NSSS supplier. Figures 1 and 2 show the flued head and weld preparation arrangement.

The flued head supplier, Sargent Industries/Airite Division, performed the buttering operation and full solution heat treatment on the twelve flued head fittings (6 per unit) for the Core Spray and LPCI systems.

The twelve flued heads were shipped to the Limerick Jobsite during the period from November, 1977 to March, 1978.

In July, 1978, during routine liquid penetrant examination of the field weld on a flued head fitting which had been installed, it was discovered that the OD contained circumferential linear indications in the Type 312 material. Subsequent examinations of the other eleven fittings, one of which is also installed, revealed similar indications. Installation/work holds were placed on all twelve flued heads and in September, 1978 one flued head was returned to the supplier for analysis.



## 2.2 Description

- 2.2.1 A total of twelve flued heads (six per unit) were buttered with Type 312 material. Eight of the fittings are used in the LPCI system and four are used in the Core Spray system. The fittings are nuclear safety related (Q-listed), ASME III, Class I. All twelve flued heads have 12" diameter process ends and 20" diameter containment sleeve ends.
- 2.2.2 The following is a description of the deficiency based on liquid penetrant examination, radiography, and analysis of a 312 weld sample removed from one flued head fitting:
  - 2.2.2.1 Circumferential linear indications are present in all twelve fittings.
  - 2.2.2.2 While indications are primarily on the OD buttered surfaces, linear indications are also present on the ID buttered surfaces.
  - 2.2.2.3 The indications are short (less than 3/4 inch), numerous, and in some cases appear around 360° of the weld end preparations.
  - 2.2.2.4 The indications are cracks. The crack width is less at the surface. The largest crack found to date is approximately 3/16" deep and 5/8" long.
  - 2.2.2.5 Subsurface cracks exist in the 312 material.
  - 2.2.2.6 No defects in the Gr. 316 base material have been found.

## 3.0 ANALYSIS OF SAFETY IMPLICATIONS

- 3.1 The affected flued head fittings are used where the Core Spray and LPCI lines penetrate primary containment.
- 3.2 If the cracks in the 312 material propagated into the 316 material and caused flued head failure, the integrity of the containment and/or the Core Spray and LPCI systems could be violated and the safety of plant operations could be adversely affected.

## 4.0 CORRECTIVE MEASURES

### 4.1 Cause

Before appropriate corrective action was initiated, the cause of the deficiency was investigated. The following is a summary of the results of that investigation:

- 4.1.1 The defects were probably present prior to shipment of the fittings to the jobsite. The indications were not discovered in the vendor's shop because the fittings were passivated with nitric acid prior to final liquid penetrant examination. It is hypothesized by Sargent that the acid in the surface irregularities was not completely removed by the spray water rinse and the remaining acid bleached the penetrant dye preventing defect observation. Penetrant testing after acid treatment is a violation of the vendor's procedure.

It has been determined by the vendor that only the twelve flued heads with Type 312 material on the weld end preparations were acid passivated prior to liquid penetrant examination.

- 4.1.2 Analysis indicates that one or both of the following factors probably caused the defects:

- 4.1.2.1 The 312 filler material used contained 40% ferrite. Filler metal with ferrite in this range has been known to crack through the formation of a brittle phase, possibly sigma. It has not been determined if the cracking was caused by the formation of a brittle sigma phase, however, it is apparent from the cracking that the weld deposit may have been brittle at some time prior to or after heat treatment or may contain areas of low strength ferrite that also could have resulted in cracking.
- 4.1.2.2 Production problems such as inadequate shielding gas coverage or inadequate control of the interpass temperature may have caused the cracks. Cracks are not present in the workmanship or weld qualification samples which were prepared prior to production welding.

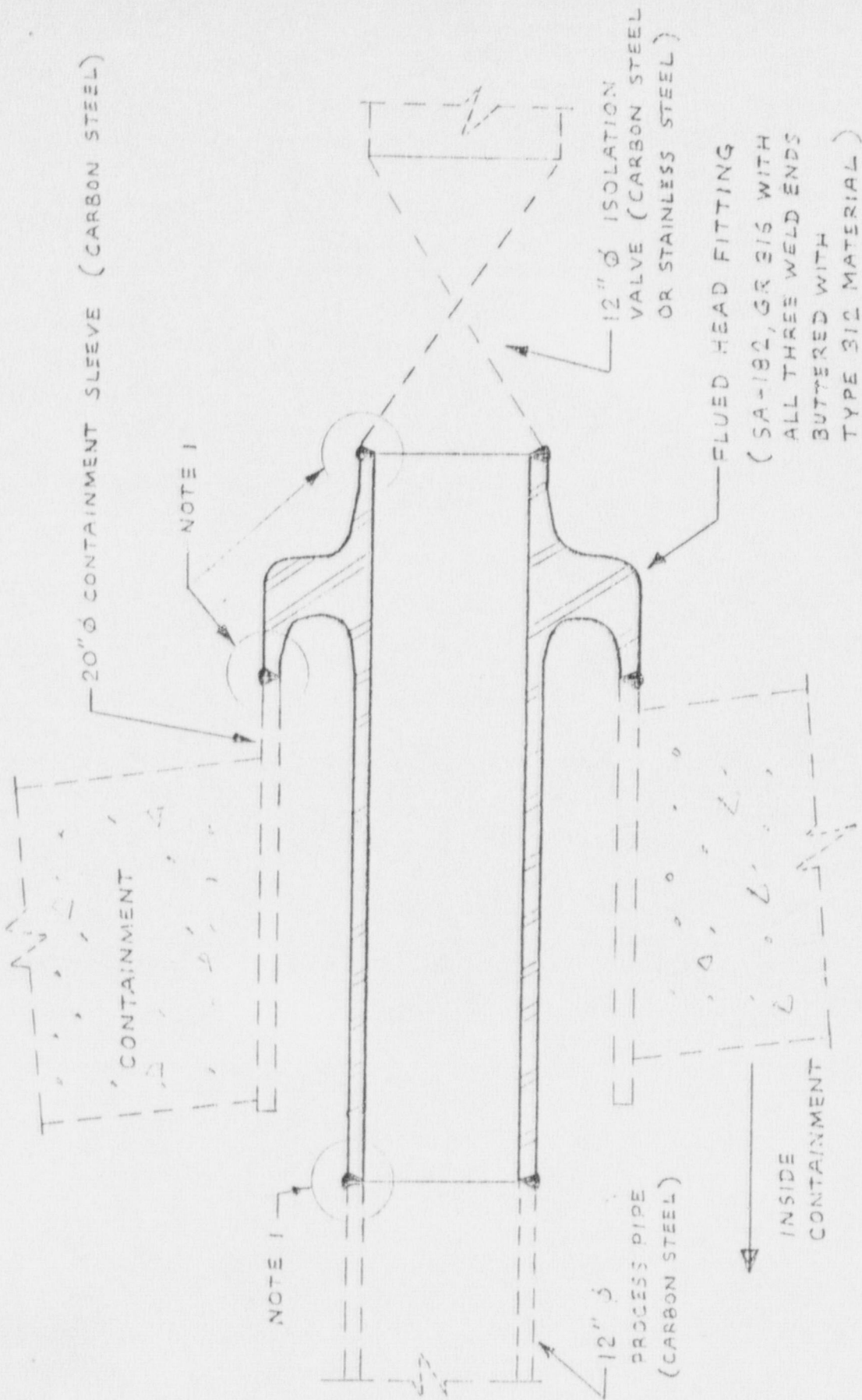
## 4.2 Corrective Action

- 4.2.1 The two installed flued head fittings will be removed.
- 4.2.2 Because of the quantity of cracks and the presence of subsurface defects it has been determined that successful repair of the 312 material cannot be assured.
- 4.2.3 Based on an analysis of cost and schedule impact one or more of the following alternatives will be taken:
  - 4.2.3.1 Remove the 312 material, re-machine weld end preparations, and use the Grade 316 flued heads in systems where IGSCC is not considered a significant risk.
  - 4.2.3.2 Remove the 312 material and rebutter using 309L material for flued head ends which will be welded to carbon steel pipe and 308L material for flued head ends which will be welded to stainless steel pipe. In addition to the requirements for ultrasonic and liquid penetrant examination which were specified for Type 312 buttering, radiographic examination would also be specified.
  - 4.2.3.3 Replacement of the flued heads with a material which would not require weld end preparation buttering.

## 5.0 CONCLUSION

The corrective action described in 4.2 above, will assure that the flued head fittings are free of defects and will present no safety hazard.





NOTE 1 : SEE FIGURE 2 FOR WELD END PREP DETAIL

FIGURE 1

TYPICAL FLUED HEAD FITTING DETAIL FOR CORE SPRAY AND LPCI

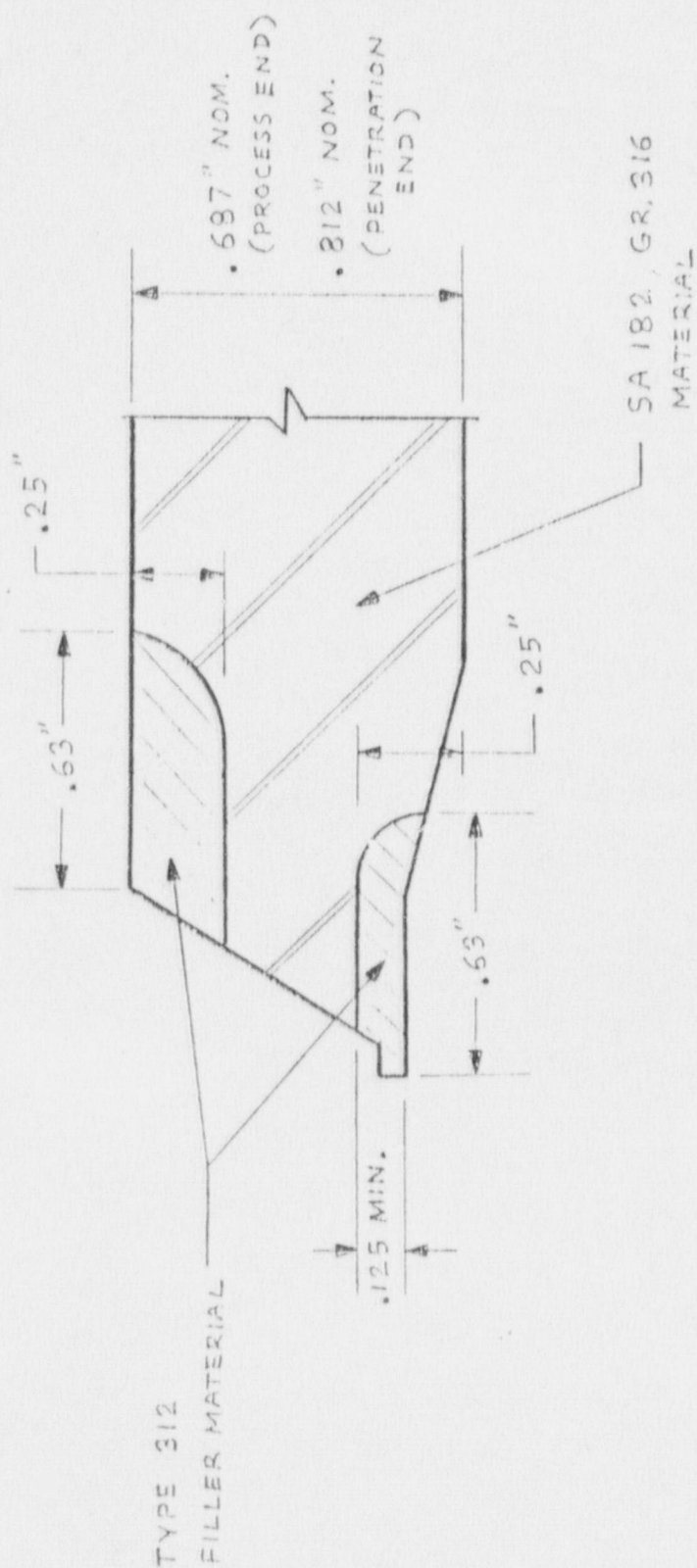


FIGURE 2

TYPICAL FLUED HEAD FITTING WELD END PREPARATION