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Thermal Striping Downstream of a Horizontal  
Elbow Under Thermally Stratified Transient  
Flow Conditions

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by

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ability.

A thermally stratified flow produced by a thermal transient passing through a horizontal elbow gives rise to large thermal fluctuations on the inner curvature wall of the downstream piping. These fluctuations were measured in a specially instrumented horizontal pipe and elbow system on a test set-up using water in the Mixing Components Technology Facility (MCTF) at Argonne National Laboratory (ANL). This study is part of a larger program which is studying the influence of thermal buoyancy on general reactor component performance [1]. This paper discusses the influence of pipe flow generated thermal oscillations on the structured thermal stresses induced in the pipe walls.

Figure 1 is a schematic of the test section and the location of the thermocouples on the system. The instrumentation was concentrated around the exit plane of the 90-degree sweep elbow, since prior tests [2] had indicated that the largest thermal fluctuations would occur within about one hydraulic diameter downstream of the elbow exit. The thermocouples depicted on the inner curvature of the piping in Fig. 1 are through-the-wall mounted sensors which for the most part, measure the near surface fluid temperature. Figure 2 is a typical plot of the temperature fluctuations as measured by the surface thermocouples 63, 64, 65 and 66 (Figure 1) under the experimentally simulated transient conditions. The test represents a thermal downramp of 6 °C/s lasting 10s at a Reynolds number of 15,000.

The largest thermal fluctuations were observed to localize in the 9:00 - 12:00 hour clock positions at about one pipe diameter downstream from the elbow exit. In this particular case, as indicated by the surface thermocouple 66 in Fig. 2, the wall is subject to a thermal fluctuation as large as 30 to 40 percent of the total temperature change imposed by the thermal ramp at the pipe inlet.

The observed fluctuations were statistically analyzed to determine their frequency content and amplitude. A typical statistical sample corresponding to the data from thermocouple 66 in Fig. 2 is shown in Fig. 3. The power spectral density is plotted against the frequency content of the signal. It is seen that most of the energy in the signal is confined to the low frequencies below 1 Hz. Power decay is nearly exponential with frequency.

Furthermore, due to the transient nature of the main event giving rise to the stratification and hence the thermal oscillations, large fluctuations were observed to occur only during 25 percent of the transient duration. These experimental results and theoretical considerations also show that the ratio of Peak-to-Peak to RMS of the temperature fluctuations is about 6.

Based on the short duration of the statistically important oscillations and the low frequency content of them it is concluded that, although seemingly strong, the larger thermal oscillations downstream of a horizontal elbow exit in reactor piping do not pose thermal striping concerns. These results were for water and therefore should be conservative as regards sodium.

#### References

1. Kasza, K. E., Kuzay, T. M., and Oras, J. J., "Overview of Thermal-

buoyancy-induced Phenomena In Reactor Plant Components," Proceedings of The Third International Conference on Liquid Metal Engineering and Technology, Oxford England, Vol. 1, pp. 187-194, April 1984.

2. Kuzay, T. M. and Kasza, K. E., "Thermal Oscillations Downstream of An Elbow In Stratified Pipe Flow," presented at the ANS Annual Meeting, New Orleans, LA (June 3-7, 1984).

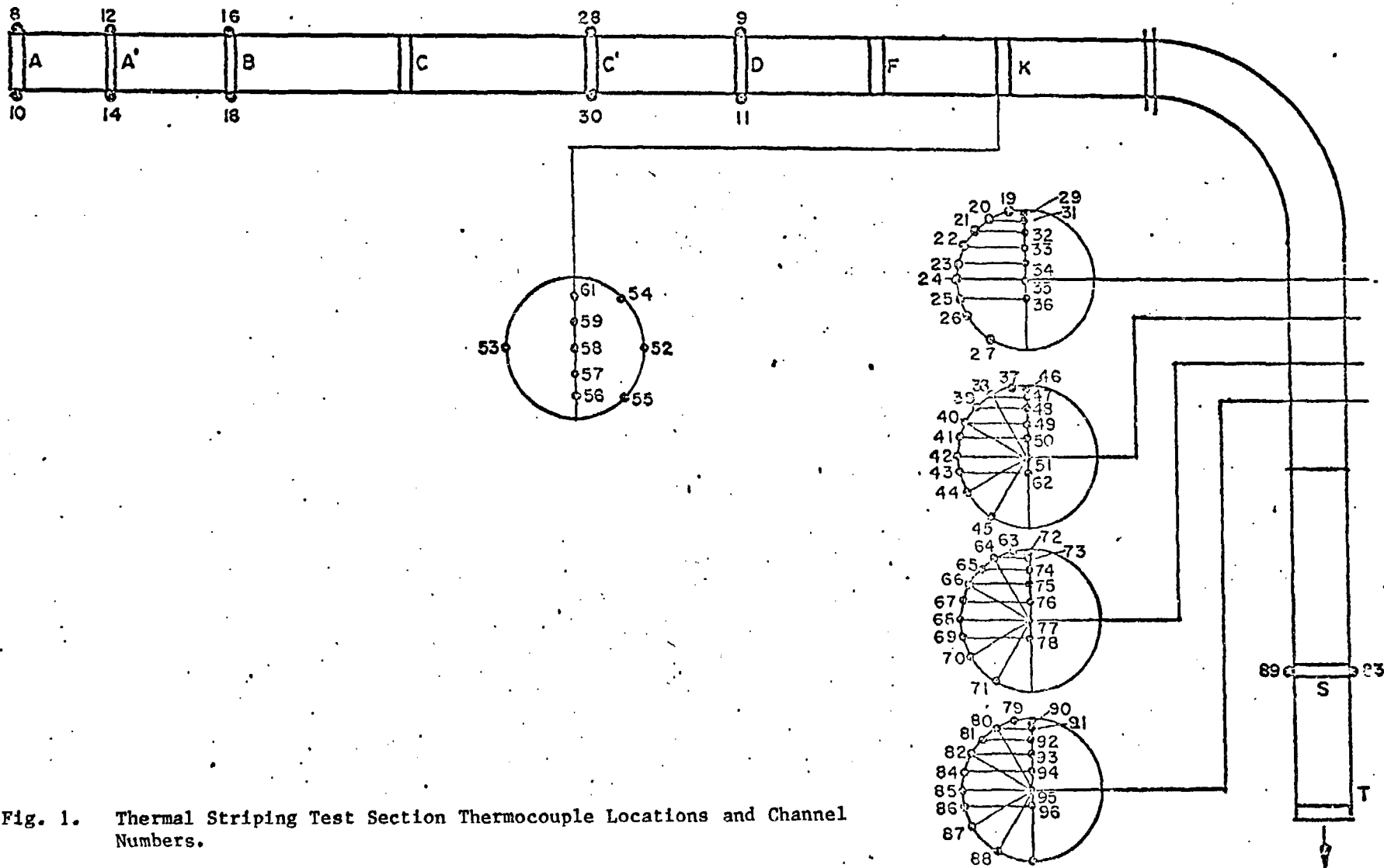


Fig. 1. Thermal Striping Test Section Thermocouple Locations and Channel Numbers.

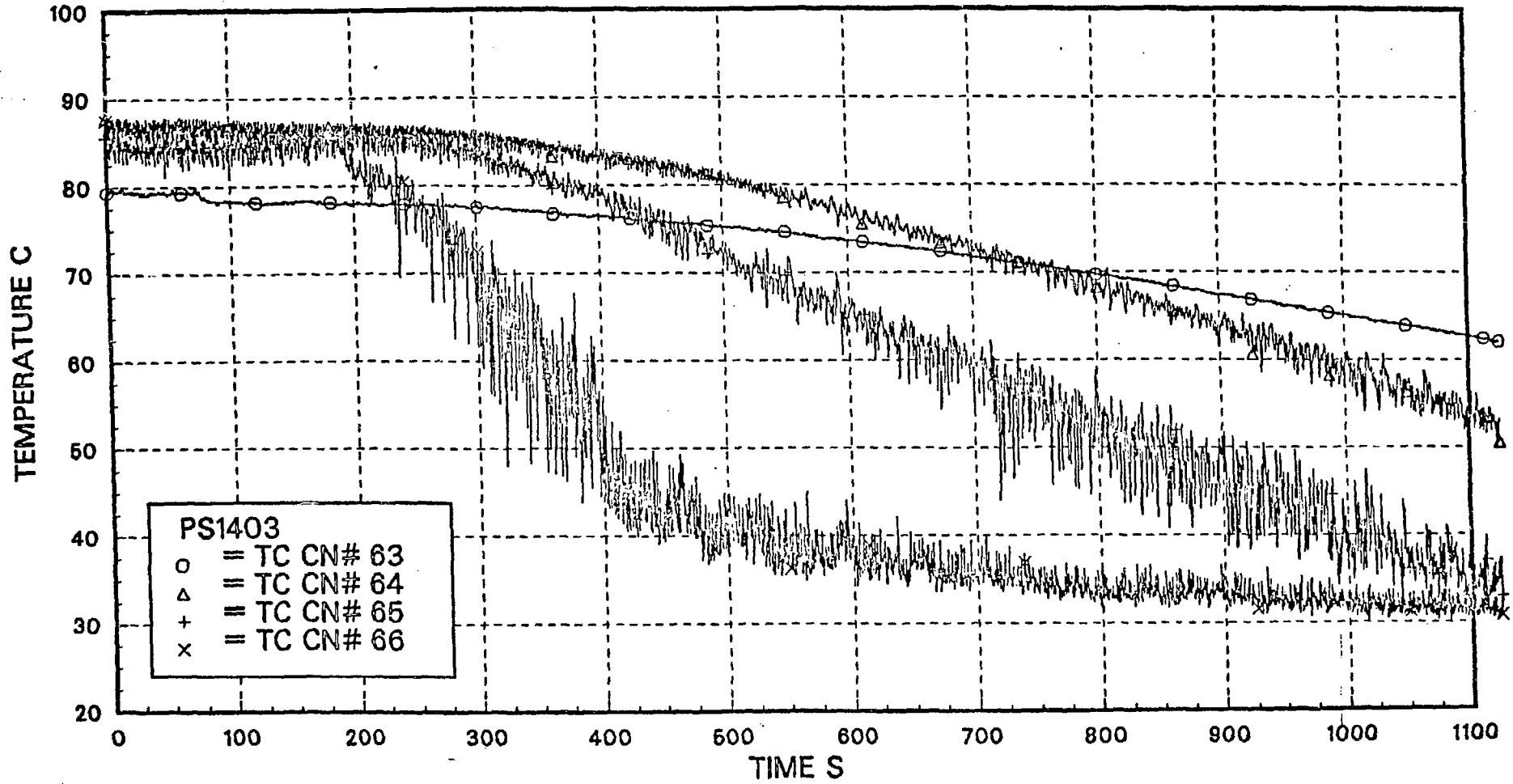


Fig. 2. Thermocouple Traces During Thermal Transient.

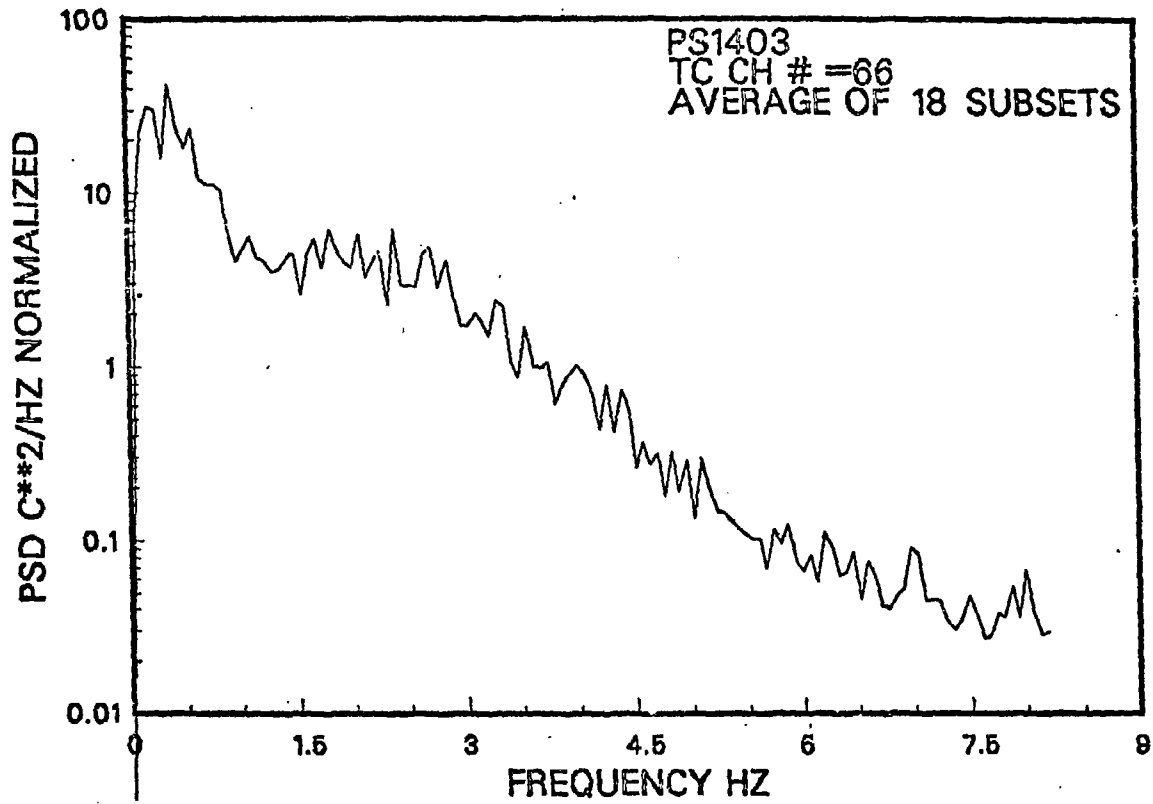


Fig. 3. Power Spectral Density for Thermocouple 66.