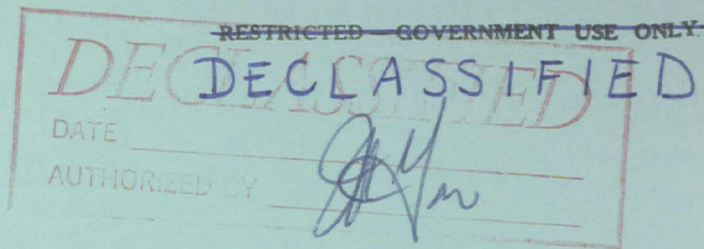


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**CANADA**

**DEPARTMENT OF ENERGY, MINES AND RESOURCES**

**OTTAWA**

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July 5, 1968

ULTRASONIC THICKNESS EXAMINATION OF  
HIGH-PRESSURE STEAM PIPING

by

W. H. Bott

Physical Metallurgy Division

*Mines Branch*

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SUMMARY OF RESULTS

An investigation has been made on high-pressure steam piping in situ using ultrasonic thickness measurements, to determine if any reduction in wall thickness had occurred as a result of corrosion.

The locations examined did not show any extreme variation in wall thicknesses, which indicates that this type of corrosion had been insignificant.

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## INTRODUCTION

In a letter (ref. 3216-509-40) dated March 15, 1968, Mr. W. M. Dicks, Chief, Ottawa Operations, Capital Region, Department of Public Works, requested that an inspection be made to determine the condition of the high-pressure steam-distribution system in the National Research Council Building, Sussex Drive, Ottawa, Ontario.

On April 9, 1968, three Mines Branch representatives, W. E. Havercroft, W. H. Bott and R. F. Knight visited the National Research Council's Sussex Street steam plant, accompanied by Messrs. J. McKenzie and A. C. Viau from the Department of Public Works.

The piping system consists of a 3-in. and a 4-in. line running parallel along a walk-through tunnel. These two lines join at a 4-in. header beyond the tunnel where they emerge from the header and proceed in opposite directions, forming a loop around the building. At the mid-section of the loop the two 4-in. lines reduce to a 3-in.-diameter pipe.

The original installation is approximately 40 years old and was specified as Schedule 40, seamless pipe. In 1960, all flanged fittings were replaced with new welded fittings and it was reported that the pipe appeared to be in excellent condition and the installation was pressure tested to 200 psi. The present installation is arranged so that the boiler pressure of 100 psi is reduced to a pipe pressure of 85 psi. Since 1960, the boiler water has been treated with amines to eliminate oxygen and to control the pH within specified limits.

In order to check the interior pipe wall for corrosion it was decided that ultrasonic thickness measurements should be made at several locations considered to be critical.

## EQUIPMENT

Thickness measurements were made of the pipe wall with a Sperry Type-UT ultrasonic thickness gauge. Test ranges of this instrument are from 0.1 to 5 in. and all measurements can be made from a test surface with a specially designed search unit or transducer. The unit will operate on its own battery supply over a surface temperature range of zero to 120°F.

A stepped-wedge steel test block is used to periodically check the accuracy of the instrument.

## PRINCIPLE OF OPERATION

The fundamental principle underlying pulse-echo measurements in solids or fluids is analogous to that used in radar except radar uses electromagnetic energy, and ultrasonic measurements are made using mechanical energy.

An electrical pulse is generated in the equipment and applied to the transducer where it is converted to a mechanical vibration or sound. The transducer is coupled to the test specimen by a suitable liquid, and pulses of high-frequency sound (5 Mhz) are transmitted into the test material. As the pulse travels through the specimen at a known velocity it encounters the back face and a portion of it is reflected at the same speed. This echo pulse travels back to the transducer where it is reconverted to electromagnetic energy and sent to the measuring and indicating circuits. In a similar manner, with a radar system, the indicators are set up to provide the distance (thickness) information directly.

## METHOD OF TEST

Seventeen locations, thought to be critical, were selected on the steam lines by Messrs. Viau and McKenzie, and were numbered for future reference. Approximately two feet of insulating material was removed from the pipe surface at each location to allow for surface preparation so that intimate contact could be made between the transducer and the surface of the material to be inspected. Paint or loose scale was removed from the areas with a coarse file.

The steam plant was closed down about 5 hours prior to the inspection to cool the system below a temperature of 100°F. This procedure was necessary because the transducer crystal must not be subjected to a temperature exceeding 120°F.

Glycerine U.S.P. was used as a coupling fluid between the transducer and the test surface. The thickness gauge was calibrated on the test block prior to commencement of the examination and was recalibrated after every three measurements.

Where possible, measurements were made on the upper and lower surfaces or on diametrically opposite sides of the pipes.

Results of the examination are given in Table 1 and are within  $\pm 5\%$ , which is the published accuracy of the instrument for the particular thickness range.

TABLE 1

Ultrasonic Thickness Measurements for Steam Pipes  
(NRC Building, Sussex Street)

| Position No. | Pipe Dia (in.) | Thickness Reading (in.) | Comment                             |
|--------------|----------------|-------------------------|-------------------------------------|
| 1            | 3              | 0.316                   | Newer Pipe                          |
| 1A           | 4              | Top 0.383               | Newer Pipe                          |
|              |                | Bottom 0.352            | Appeared to be manufacturing defect |
| 2            | 3              | 0.305                   | Newer Pipe                          |
|              |                | 0.306                   |                                     |
| 2A           | 4              | 0.373                   | " "                                 |
| 3            | 3              | 0.316                   | " "                                 |
| 3A           | 4              | 0.401                   | " "                                 |
| 4            | 4              | 0.353                   |                                     |
| 5            | 4              | 0.361                   | Reading taken close to elbow        |
| 6            | 4              | 0.361                   |                                     |
| 7            | 3              | Top 0.326               |                                     |
|              |                | Bottom 0.326            |                                     |
| 8            | 3              | 0.326                   |                                     |
| 9            | 3              | 0.326                   |                                     |
| 10           | 3              | 0.322                   | Pipe very warm                      |
| 11           | 4              | 0.350                   |                                     |
| 12           | 4              | 0.355                   |                                     |
| 13           | 4              | 0.353                   |                                     |
| 14           | 4              | Top 0.250               | New Pipe                            |
|              |                | Bottom 0.255            |                                     |
| 15           | 4              | 0.357                   |                                     |

## CONCLUSIONS

1. Areas tested, on 3-in.-diameter pipes, vary in wall thickness from 0.316 to 0.326 in. except for position No. 2 which has a wall thickness of 0.305 in. and was installed at a later date.
2. Top and bottom readings, which were taken when possible, show little or no variation on 3-in.-diameter pipe.
3. The 4-in.-diameter pipe varied in wall thickness from 0.350 to 0.361 in. except at positions No. 1, 2, 3, and 14 respectively. These particular sections were installed at a later date than the original installation.
4. Thickness readings varied from 0.352 to 0.383 on the top and bottom of the 4-in.-diameter pipe at position No. 1. A manufacturer's irregularity was noted at this location.
5. It is recommended that thickness measurements should be repeated at the same locations in approximately two to three years.