PANEL DISCUSSION

The panel discussion was a wrap-up of the symposium. Each of a group of experienced and knowledgeable panelists started off the session by giving his views on a particular area of interest. This was followed by a brief but lively period of questions and discussion from the floor; some questions were directed to individual panelists while others were addresed to the panel as a whole.

PANELISTS

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Synopsis of Panelists' Comments

The technology of radiation thermometry, albeit sometimes complex, is approaching maturity. Virtually all major problems involving applications are solvable, but work remains to be done by way of developing methodology for some of the more sophisticated applications. The problems of greatest concern to the panel revolve around education of the user and designer and the concomitant problem of a reasoned engineering approach to the development of solutions to specific new applications. The work of Martocci and Mihalow was pointed out as a clear example of this; the problem was tractable, but a significant effort was required to solve it. Many users do not know enough about radiation thermometry to anticipate the problems involved in such projects. The success of this and other seemingly difficult applications clearly points out not only that the fundamentals are well known but also that a wide range of generally adequate instrumentation can be obtained from commercial sources. Part of the education problem stems from the fact that the instrument manufacturers have become the major repository of readily available applications assistance. Clearly, a better job can be done, and the educational task should not be solely the responsibility of the instrument manufacturer.

Indeed, as this technology increases in its importance to process control, quality control, and manufacturing engineering, it becomes the challenge of management to ensure that both the engineering and maintenance staffs become better informed in the selection and use of radiation thermometers. The fact that these sensors presently play a major role in several manufacturing industries while in many companies there is virtually no understanding of them is a clear indication that both management and engineering have, in some cases, been seriously deficient in their roles. It is to be hoped that symposia such as this one can call attention to this dire situation.

A warning was raised by one panelist, who pointed out that some users felt that they were taken advantage of or ill-advised after the fact by having depended solely on the advice of an instrument supplier salesman. The uninformed user is always at risk in such a situation, and an inadequately trained instrument salesman can make mistakes. The solution is the same in both cases: improve the knowledge of both the vendor and the user. Educational material provided by sources independent of the manufacturers and sales personnel would help in this respect.

ASTM recognizes the serious need for educational information based on sound principles, and that standards in the area of terminology, instrument test methods, and calibration practices would go a long way toward helping overcome the education bottleneck. ASTM Subcommittee E20.02 on Radiation Thermometry is now in the process of developing standards and an engineering-level applications manual for radiation thermometry. In addition, ASTM has actively solicited and encouraged a more scholarly, detailed work, which has been supported by the National Bureau of Standards (NBS) and which will shortly be published as an NBS monograph entitled the *Theory and Practice of Radiation Thermo-*

metry; this monograph has been edited by two of the participants in this symposium, D. P. DeWitt and G. D. Nutter.

Steel Industry Successes and Problems

Since primary steel manufacturing historically has been one of the principal users of radiation thermometers, two panel members were invited from steel companies. Their presentations addressed different aspects of the use and maintenance of radiation thermometers. From the following edited comments provided by the panelists, it is clear that frequent calibration is required and that serious users either have in-house calibration facilities or use those of contract laboratories to achieve the same end.

Calibration of Industrial Radiation Thermometers

The entire metallurgical control of steel processing from the basic oxygen process (BOP) vessel to the strip annealing furnaces within a plant depends on consistent use of standards by which radiation thermometers and thermocouples are calibrated. Uniform control from plant to plant, including use of Plant A practices at Plant B, depends on all plants using the same temperature standards traceable to the U.S. National Bureau of Standards. Standards activities have been casualties of ''economy drives'' in many plants. Although the economy of processing may appear to suffer as a result of the cost of such calibration activities, the need for checking temperature-measuring devices periodically against standards is continuous, and failure to provide adequate calibrations can be even more costly. When calibration and standardization resources in manufacturing plants must be cut back, it is suggested that these services be picked up by outside organizations specializing in such activities. The independent testing laboratory is a candidate to learn the necessary techniques, acquire the equipment, and produce traceable calibrations of temperature-measurement equipment for their customers. The knowledgeable manufacturer's representative would provide a most valuable service to his radiation thermometer customers if he would provide such a service, as would the field office of an instrument supplier. It is hoped that this challenge will be taken up; a profitable new service would be generated for the instrument supplier, and users would be saved the expense of maintaining standards.

An additional benefit to users would be a ''calibration tag'' affixed by the calibrator with the date of the last calibration and a target date for the next calibration, to alert users when a radiation thermometer may be out of calibration and should be checked. A service with fast turnaround and easy accessibility to plant operators would be a real benefit to plants not having an internal calibration facility.

Calibration and Verification of On-Line Radiation Thermometers

During the last 12 to 15 years, numerous heat-treating and rolling facilities either have been updated or initially instrumented with respect to temperature measurement and control. Old "total radiation" thermal sensor systems have been replaced by today's state-of-the-art radiation thermometers. These applications include continuous strip annealing furnaces and hot strip rolling mills.

Application of these sensors necessitated the establishment of correct emissivity values to assure that correct temperatures would be indicated by the radiation thermometers. Four methods are employed in determining emissivities in common industrial practice:

1. Use of the "reflective hemisphere" pyrometer. This instrument has a gold hemispherical cup that surrounds the target, creating a small blackbody enclosure over the surface. This feature reduces errors due to emissivity variations to a small value. For an emissivity of 0.6, a correction of only 3.3°C (6°F) at 815°C (1500°F) is then necessary. The placement of a black hemisphere over the target then can be used to obtain additional data, permitting the determination of the emissivity value.
2. Temperatures determined utilizing the gold hemisphere are compared to the on-line radiation thermometer, with the emissivity control being adjusted until the two temperature indications agree.

These two methods rely on good application practice in areas of measurement in which high levels of reflected energy are not present, the sight path is clear, etc.

3. Attachment of a thermocouple to the material under test. This is usually accomplished by spot welding the thermocouple to the surface of a moving strip entering a continuous annealing furnace. A payoff spool has been developed for this test technique and has been used at line speeds of up to 1m/s (3.3 ft/s).
4. Submission of samples of material to the thermometer manufacturer.

In all instances, one or more of these methods are utilized along with published emissivity values.

More often than not, the reinstrumentation or initial application of thermal sensors to an existing process provides measured temperatures that are viewed skeptically by operating and metallurgical personnel.

Some of the methods just described are employed to verify the on-line thermometer indications. The instrument with the gold hemisphere is utilized to determine strip temperatures in continuous annealing furnaces that employ protective atmospheres.

What is called the continuous thermocouple method also is employed for continuous annealing processes. It has been found that this method should be used on processes that employ an air or oxidizing furnace atmosphere. Erroneous temperature indications can be obtained on low emissivity surfaces—around 0.6 and below—due to perturbing the strip surface temperature while spot-welding the thermocouple to the moving strip.

The method chosen to check on-line radiation instruments in the hot strip rolling area is also the gold hemisphere sensor. In this application, a skid is placed on the sensor housing with the sensor being placed on the moving material. This test is conducted at several locations throughout the hot rolling area, slab mill, roughing stands, finish stands, and also at the coilers. In addition to being used to validate new setups, these techniques are employed to check the on-line systems on a periodic basis. In some instances, the plants have purchased the necessary equipment and personnel have been trained in the proper use of the instruments.

The installation and use of radiation thermometers has necessitated the use of blackbody calibration facilities throughout a division of one major steel producer. These reference furnaces also are checked on a regular schedule with traceable secondary standard radiation sensors to assure calibration accuracy.

What has been described here has in numerous instances reduced thermometer problems in the mills, produced accurate, repeatable temperature measurement and control, and in many cases shown an improvement in product quality.

We see a need for ASTM to develop test methods for the checking of radiation thermometers in use.

Looking to the Future

The 1982 International Temperature Symposium in Washington, DC showed that exceptional progress in the understanding and use of industrial and metrological radiation thermometry has been achieved in the previous ten years. Most notable was the extensive work carried out in Japan, principally through a cooperative effort among the government standards laboratory, steel companies, and instrument manufacturers. This appears as much a challenge to us in the United States to "get our act together" as it is an example of what can be achieved through mutual cooperation of interested parties. There are still problems to be solved, as has been demonstrated here, and they generally revolve around improvements in education and standards.

Future standardization of test methods, calibration procedure, and practice are only part of what is clearly needed. The fairly recent introduction of simple instruments with linearized 4 to 20 mA outputs heralds other likely improvements in instrument capability. Since about 80% of the radiation thermometers sold by nearly all vendors have spectral band passes in common regions, such as 0.9, 2, 5, and 8 to 14 μm, it would seem feasible—and desirable—to consider standardization of the wavelength specification of these instruments.

Questions and Discussion from the Floor

The discussion was relatively brief and centered around the problems of getting management's attention. A variety of views were given. Among the key points made and generally agreed upon were:

1. It is important to keep management informed of the successes with radiation thermometry because their view is generally guided by the payback. Symposia like this one help provide this sort of information and a view of what it takes to get the job done.
2. The key people who influence steel industry management are found in the Association of Iron and Steel Engineers (AISE) and the American Institute of Mechanical Engineers (AIME). Clearly the example of the establishment of the National Conference of Standards Laboratories (NCSL), resulting from Department of Defense activities, could be used as a guideline or as a resource for meeting industrial needs in radiation thermometry.
3. Corporate educational efforts, which appear to be badly needed in radiation thermometry, usually pay off when they involve improving individual workers' jobs.
4. The European economic community is developing a standard on radiation thermometry, and it must be considered in the ASTM standards development.
5. Educational efforts aimed first at management and second at the shop or mill level must continue.