

Roof Strap Flame Cutting Experiments at the National Institute for Occupational Safety and Health Lake Lynn Experimental Mine

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Introduction

Flame cutting experiments were conducted on a metal roof strap (figure 1) on August 22, 2006 at the National Institute for Occupational Safety and Health (NIOSH), Lake Lynn Experimental Mine (LLEM) by NIOSH researchers. These experiments were requested by the Mine Safety and Health Administration (MSHA). The objectives of these experiments were to determine the temperatures histories of hot particles and hot metal strips during and after flame cutting. The instrumentation used in these experiments was an AGEMA Thermovision 550 infrared camera (IR) system and a laptop computer running the software ThermoCam™ Researcher 2001.



FIGURE 1. MSHA EMPLOYEE HOLDING METAL ROOF STRAP

Emissivity Experiments at PRL

In order to get accurate temperature measurements from the metal roof strap flame cutting experiments, emissivity experiments were conducted on samples of each metal roof strap that was flame cut at LLEM at NIOSH Pittsburgh Research Laboratory (PRL). The samples were painted (approximately 50 % of the area) with high temperature black paint. These strips were placed on a hot plate and heated until thermal equilibrium was reached. The IR camera emissivity was set to 1.0 and the black painted area temperature was measured and recorded. The temperature of the unpainted area was then measured and recorded. The emissivity was then readjusted so that the unpainted area temperature was equal to the initial temperature of the black painted area. Figure 2 show the experimental setup and Table 1 shows the results of these experiments. The average emissivity of the unpainted metal strips was 0.87. This value was used for analysis of the thermal data from the LLEM flame cutting experiments.

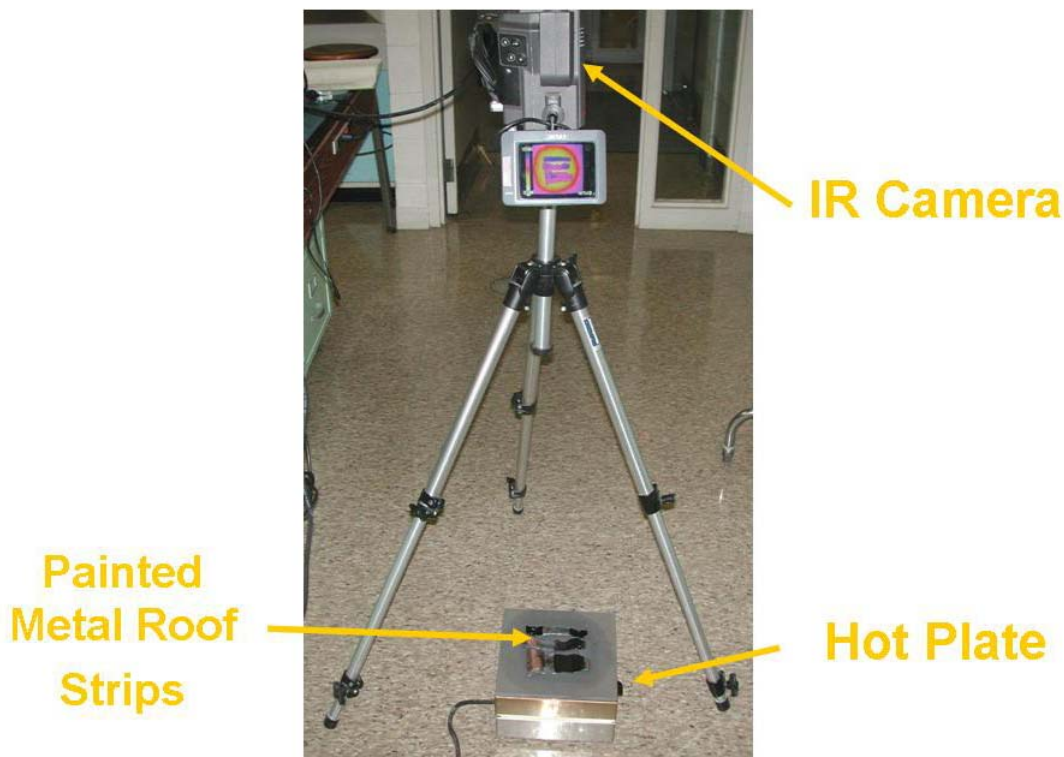


FIGURE 2. EXPERIMENTAL SETUP TO OBTAIN EMISSIVITY VALUE OF A METAL ROOF STRAP

Cut Metal Roof Strip ID	Emissivity	Painted Temperature ° F	Adjusted Emissivity	Unpainted Temperature ° F
4	1.0	717	0.85	715
6	1.0	700	0.85	700
7	1.0	694	0.8	690
9	1.0	722	0.9	720
10	1.0	670	0.88	670
11	1.0	753	0.95	750
Average	1.0	709	0.87	708

Table1. Emissivity Experimental Results

Omega Block/Steel Strap Experiments at LLEM

In these series of experiments, an Omega block was placed on top of the metal roof strap and an infrared camera was positioned on the opposite side of the Omega block where the flame cutting was performed (figure 3). The metal strap was cut from underneath. A NIOSH employee performed the flame cutting. Some of the hot particles traveled thru the two troughs located on the metal roof strap (figure 4), underneath the Omega block to the other end metal roof strap, and fell to the mine floor. The thermal histories of several hot particles, shown in figure 5, were recorded with the thermal imaging camera. In figure 5, the hot particles are identified as AR01-ARO6. The maximum temperatures are shown in table 2 and ranged from 931 °F – 1403 °F. The maximum temperature observed was 1403 °F for the particle identified as AR05.

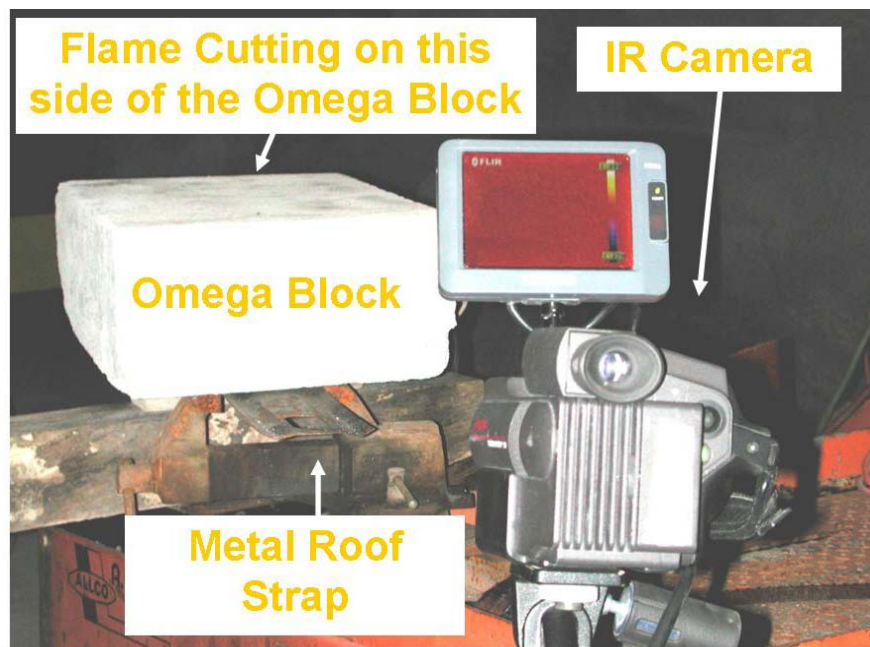


FIGURE 3. EXPERIMENTAL SETUP OF OMEGA BLOCK AND METAL ROOF STRAP

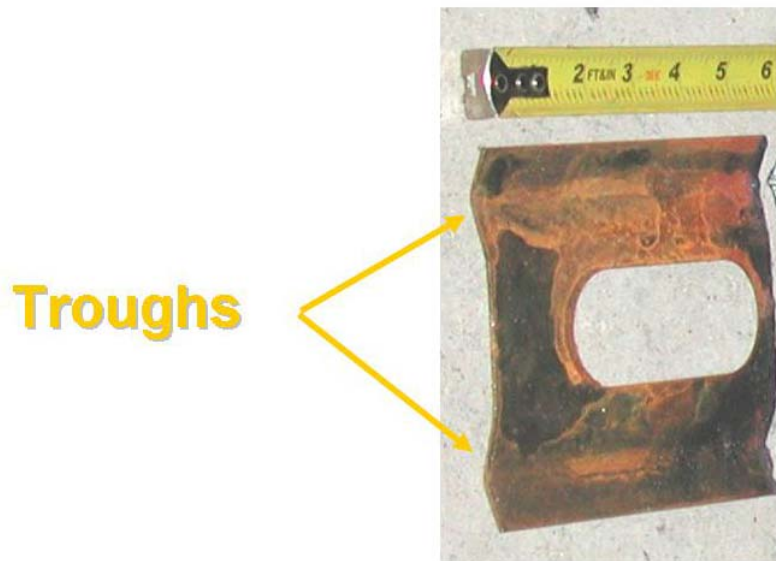


FIGURE 4. TROUGHS LOCATED IN THE METAL ROOF STRAP

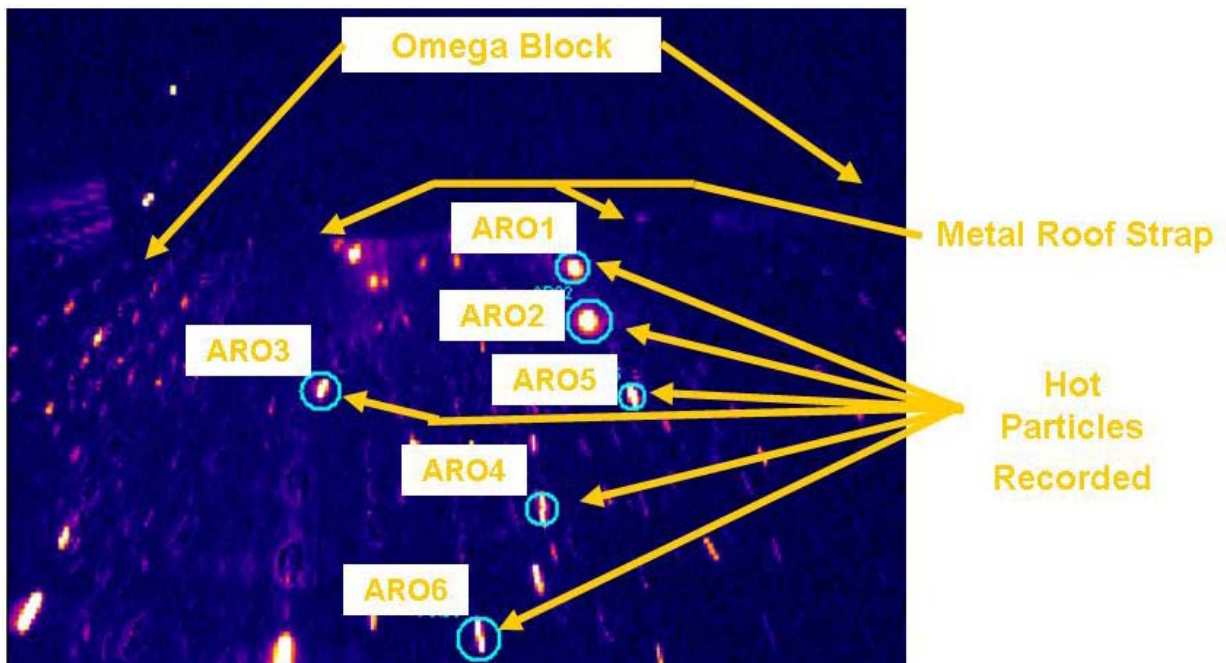


FIGURE 5. HOT PARTICLES TEMPERATURE THAT WERE RECORDED

Particle ID	Maximum Temperature °F
AR01	1378
AR02	1369
AR03	1400
AR04	931
AR05	1403
AR06	1088

Table 2. Maximum Temperatures of the Hot Particles Areas 1 - 6

Hot Metal Strip Experiments

In these experiments, metal strips ranging from ½ -in to 1.5-in were flame cut from a metal roof strap (figure 6). The infrared camera was positioned to view the hot metal strips being cut (figure 7). The time-temperature was recorded every 200 milliseconds during these experiments. The temperature history of a 1.5-in hot metal strip that was cut at a normal cutting speed is shown in figure 8. The temperature of the strip remained above 1000 °F for 19 seconds. Figure 9 shows the time-temperature history of a ½” hot metal strip cut at a slower cutting speed. In this experiment, the temperature remained above 1100 °F for 10.5 seconds. Figure 10 shows all strips cut from a metal roof strap.

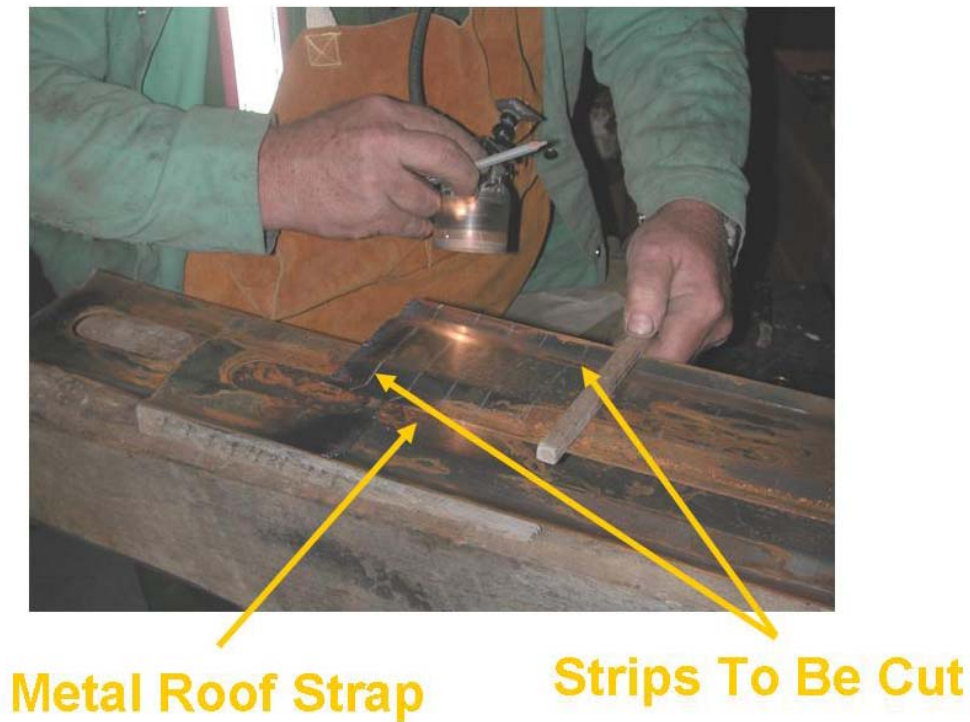


FIGURE 6. METAL STRIPS BEING MARKED

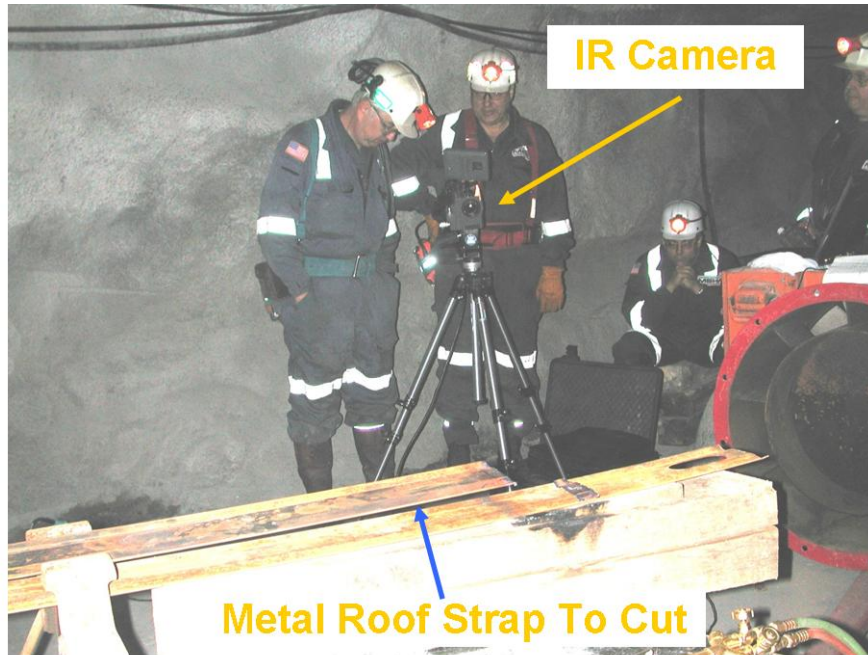


FIGURE 7. INFRARED CAMERA POSITIONED TO VIEW METAL ROOF STRIPS TO BE CUT

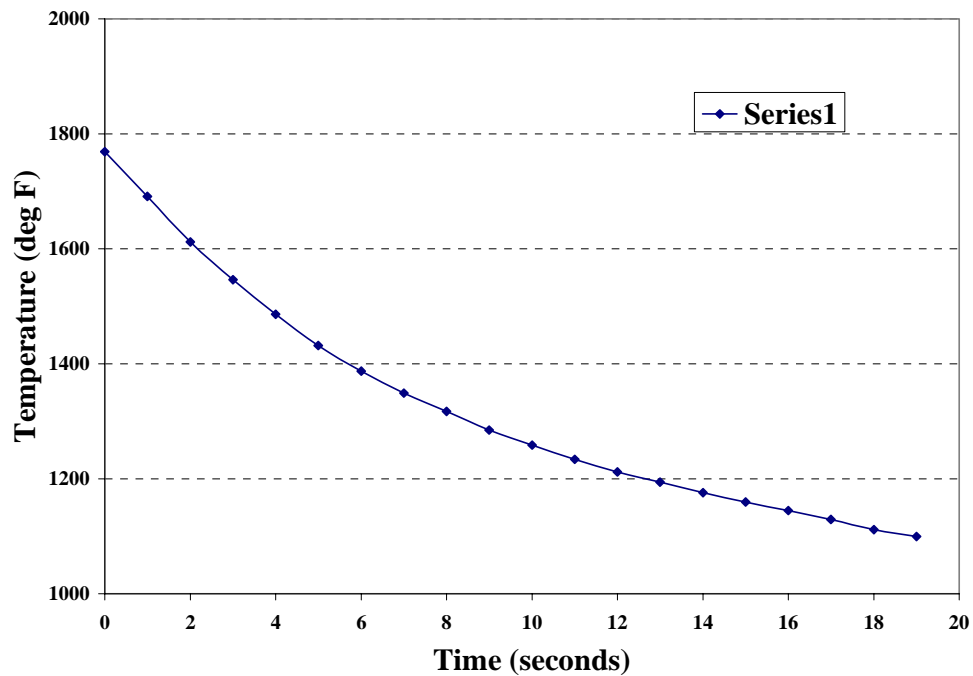


FIGURE 8. TEMPERATURE VERSUS TIME FOR A 1.5-in METAL ROOF STRIP

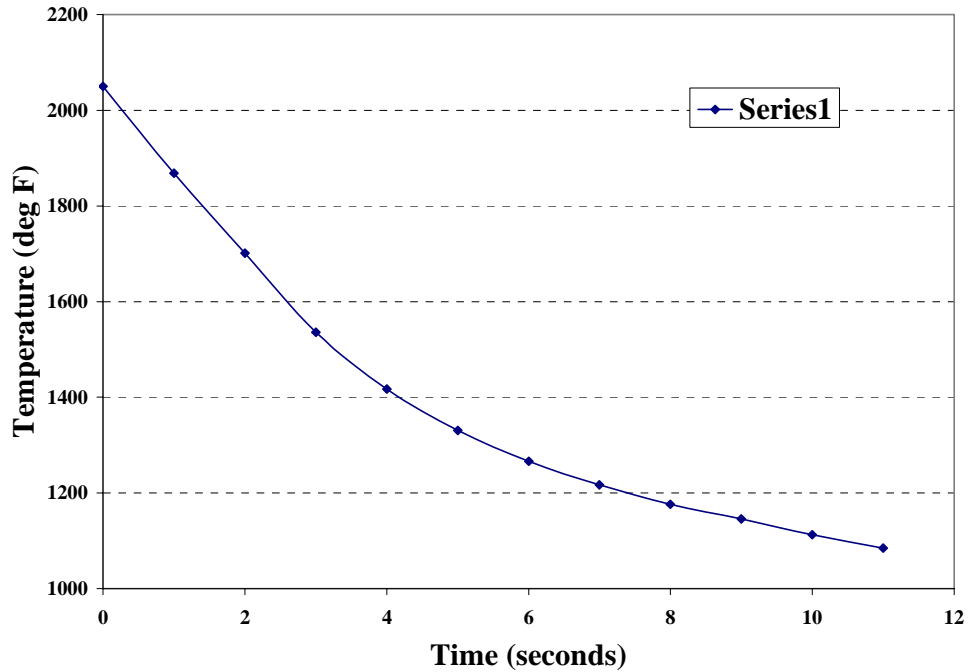


FIGURE 9. TEMPERATURE VERSUS TIME FOR A 1/2-in METAL ROOF STRIP

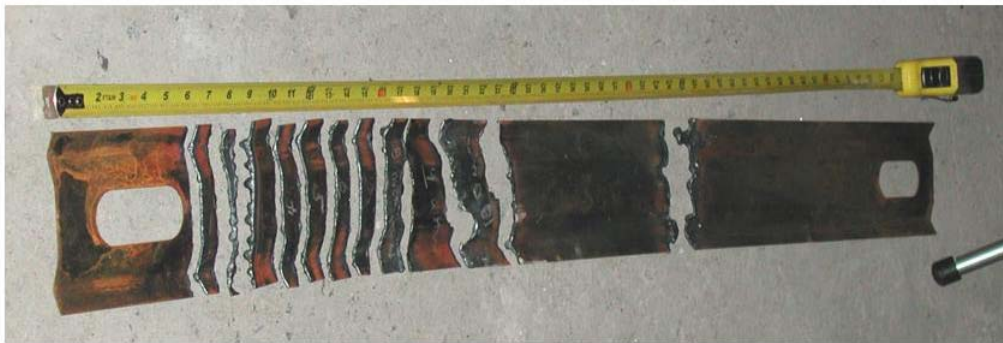


FIGURE 10. STRIPS CUT FROM THE METAL ROOF STRAP

Summary

Flame cutting experiments were performed on a metal roof strap to determine the time-temperature histories and maximum temperatures of hot particles and hot metal strips during the flame cutting operations. In the hot particle experiments, maximum hot particle temperatures ranging from 931 °F to 1403 °F were observed. In the hot metal strip experiments, temperatures of the hot metal strips remained above 1100 °F for 10.5 to 19 seconds depending on the size of the metal strip and the rate at which it was cut.