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FUEL MELTING AND RELOCATION IN THE ADVANCED TEST
REACTOR: SIMULANT EXPERIMENTS IN AN OPEN GEOMETRY

by

JEFFREY SCOTT GUNDERSEN

A thesis submitted in partial fulfillment of the
requirements for the degree of

Master of Science
(Nuclear Engineering and Engineering Physics)

at the
UNIVERSITY OF WISCONSIN - MADISON

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Abstract

FUEL MELTING AND RELOCATION IN THE ADVANCED TEST REACTOR: SIMULANT EXPERIMENTS IN AN OPEN GEOMETRY

Jeffrey Scott Gundersen

Under the supervision of Professor Michael L. Corradini

Fuel melting and relocation in the Advanced Test Reactor were explored. Wood's metal and R-113 were used as the fuel and coolant simulants. Two situations were simulated, a large loss of coolant accident, and a complete loss of flow accident. A clear wall was used as one of the simulated ATR core fuel plates, thus enhancing visual observation capability while preserving the geometry of the ATR. The experimental results are in the form of a videotape of the experimental runs, the associated temperature profile data, and observations of the test runs.

Experimental results indicate that the melting fuel follows the paths created by previously melted metal. When these rivulets flow into the coolant, they solidify and thicken due to the continued mass flow to the solidified location. The gap between fuel plates can be blocked in these locations but the total cross sectional area between fuel plates will not be completely filled in because the molten metal continues to follow the rivulets, and flow around obstructions, rather than flowing evenly as in sheet flow.

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Chapter 1: Introductory Information

This paper discusses the experiment undertaken by Mark Handrick and the author for the degree of Master of Science in Nuclear Engineering at the University of Wisconsin - Madison. The work was done under the direction of Professor M. L. Corradini of the department of Nuclear Engineering and Engineering Physics. The main result of this project is the videotaped experimental runs. This thesis provides background information, a description of the experimental runs, and an analysis of the results.

1.1 Project Description

The Advanced Test Reactor (ATR) is located at the Idaho National Engineering Laboratory and operated for the United States Department of Energy by EG&G. The

ATR is used for materials testing, specifically testing at high neutron fluxes up to 1×10^{15} n/cm²-s. The reactor is shaped like a four leaf clover, each of the lobes comprising a section of the core. The fuel assemblies are made up of 19 fuel plates each, separated by 1.98 mm. The active length of the assemblies is 1.22 m. Light water is used as the core coolant. [1]

At the high fluxes available inside of the core, wear testing, which may have taken too long in another reactor, can be done in a much shorter time in the ATR. However, due to the high power density required, there is concern about one of the sections of the core melting. If this were to occur, it would be important to know whether the melting fuel will completely obstruct coolant flow, thus enlarging the affected region of the core. The goal of this experiment is to observe the dynamics of melting metal in a coolant, keeping the parameters similar to those of the ATR where important.

1.2 Materials Choices

The ATR fuel is an intermetallic compound of uranium and aluminum with aluminum cladding. The melting point of the aluminum cladding is 660°C. The fuel matrix melting point is variable because the different forms of the UAl_x all have different properties, but the difference between the fuel and elemental aluminum melting temperatures is not significant. [2, p.3] The coolant used is water pressurized to 355 lb/in² at the inlet of the core. Clearly we could not duplicate the ATR core conditions, so we instead chose materials which could be used to simulate the ATR properties. In our experiment, we used an alloy made up of 50% Bi, 26.7% Pb, 13.3% Sn, and 10% Cd [3] as the fuel simulant. The particular alloy we used is called Belmont Alloy 2505 but is

commonly known as Wood's metal. Wood's metal was chosen because of its low melting temperature of 70°C. To cool the metal we needed a coolant which would boil at a substantially lower temperature. R-113 which boils at 47.6 °C was chosen. Table 1-1 lists some properties of the metal and coolant.

Table 1-1: Materials Properties

Property	Wood's Metal [3]	R-113 [4]
Melting Point	70°C	N/A
Boiling Point	N/A	47.6°C @ 1 ATM
Thermal Conductivity	52.3x10 ³ W/(m °C) (solid)	7.61x10 ³ W/(m °C) (vapor)
Specific Heat	0.168 kJ/(kg °C)	0.674 kJ/(kg °C) (vapor)
Molecular Structure	N/A	CCl ₂ F-CCIF ₂
Density	9.38x10 ³ kg/m ³	1.56x10 ³ kg/m ³ (25°C liquid) 7.38 kg/m ³ (saturated vapor)
Heat of Vaporization	N/A	146.8x10 ³ J/kg

The experiment simulates a fuel melt accident due to a loss of coolant. Using resistance heaters inside of an aluminum box upon which the Wood's metal is cast, the R-113 is boiled off. A pump is used to control the coolant level. Figure 1-1 is a diagram of the entire experimental setup.

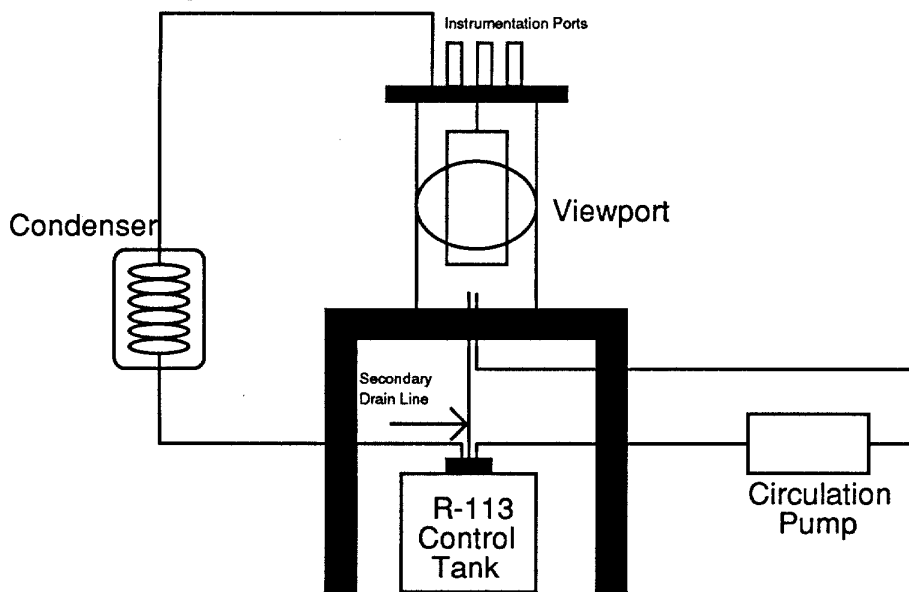


Figure 1-1: Experiment Schematic

The condenser consists of a wound copper tube immersed in an ice bath. A pressure indicator and relief valve are located on the top to keep conditions in the glass tube within the set parameters. The relief valve can be used when the condenser, which is not pumped, does not condense enough R-113 vapor, causing the pressure to increase in the tube.

The coolant reservoir is simply the 15 gallon tank in which the R-113 coolant was supplied. A rubber stopper was outfitted so that inlet and outlet coolant flow could occur through copper tubing without releasing the refrigerant to the atmosphere.

On the front of the glass tube is a port onto which a plastic plate is bolted, allowing for convenient videotaping of the experiment in progress. The top plate has access ports for the heater wires and thermocouples.

The instrumentation ports are for power wires, thermocouples, and a pressure gauge which measures the overall tank pressure.

Figure 1-2 is a diagram of the aluminum heater assembly.

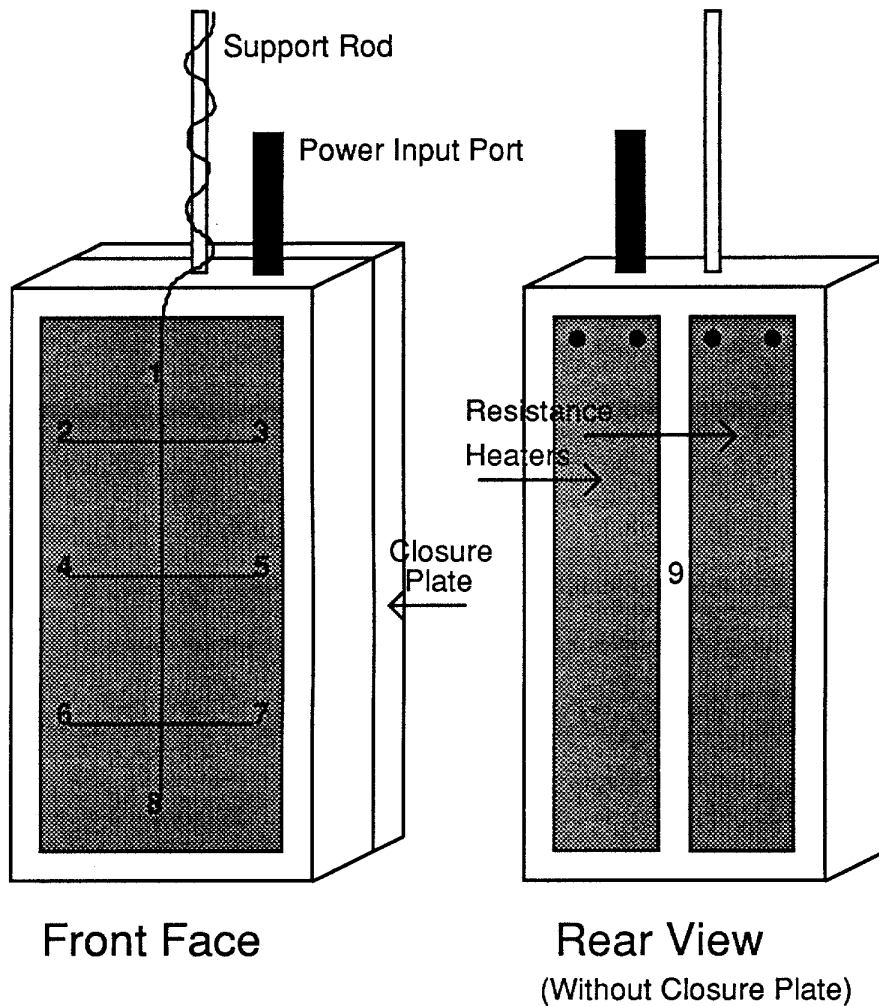


Figure 1-2: Aluminum Housing Box and Casting Surface

A depression, 3.2 mm deep, is milled into the front face to hold the Wood's metal. The edges of the depression are milled at a 45° angle to help hold the cast metal on while the experiment is being run.

The box is instrumented with thermocouples which give the temperature of the Wood's metal at several points on the cast face. Grooves were milled into the front aluminum face so the thermocouple wires could be placed under the cast Wood's metal

without significantly disrupting the surface. Figure 1-2 shows the locations of the thermocouples according to how they were numbered for data collection. Thermocouple 9 is inserted into a small hole in the interior of the aluminum box. This was necessary to stay within temperature safety limits inside the apparatus. Thermocouple 10, which is not shown, was used to measure the bulk temperature of the coolant.

The grooves serve another purpose by helping to hold the Wood's metal on while running the experiment. Originally, we had many problems trying to hold the cast metal in place as the aluminum surface temperature increased above the melting temperature of the Wood's metal. In the clear wall phase of the experiment, the problem was solved by tilting the box about 5 degrees off vertical so the bottom edge could support the metal better. However, this could not be done for the parallel heated plates so the grooves were helpful.

The specifications of the resistance heaters [5] are as follows:

Company:	Watlow
Power:	500 W at 120 V
Heated Area:	66 cm ²
Heat Flux:	7.6 W/cm ² at 120 V
Material:	Stainless Steel

They are operated using a variable AC source. The heat flux as a function of voltage is approximately linear with full power at 120 volts AC input. We ran the experiment at two power levels, 80% and 100%, corresponding to 6.1 and 7.6 W/cm² respectively. This heat flux is obviously greater than what reached the Wood's metal due to losses which are estimated to be 15% due to conduction out the sides and back of the aluminum assembly.

1.4 Data Acquisition

A Keithley 575 measurement and control system was used in conjunction with an AIM 7 thermocouple input module card for temperature measurement. KDAC 500 PC software was used to control the hardware.

A pressure gauge was attached to the top flange so that the pressure in the vessel can be monitored. The actual values were not recorded since it was just used for safety purposes.

A video camera was used to record experiment runs on tape. The resulting videotapes as well as notes made during the experimental runs were used to make the conclusions regarding the melting metal flow dynamics for various parameters.

1.5 General Experimental Procedure

The thermocouple wires had to be placed in their correct positions prior to casting the Wood's metal. This involved taping the wires onto the aluminum face, with the temperature sensing end turned slightly outward so the temperature of the Wood's metal would be measured rather than that of the aluminum.

The Wood's metal was then cast onto the aluminum plates. The stored Wood's metal was melted by using heaters imbedded in the walls of its storage cylinder. The experiment's internal resistance heaters were used to heat the surface of the aluminum

assembly so that the Wood's metal could be spread around, creating a uniform layer before solidifying. The cast thickness was 3 ± 0.2 mm thick for each experimental run.

Once the Wood's metal had solidified, the aluminum apparatus was assembled and placed into the glass tube, affixing the top flange. Power was supplied to the resistance heaters, and the thermocouple connections were then made. The gap between the plates was made by using spacers to separate the parallel plates by the desired amount.

Once the glass container was sealed and instrumentation in place, coolant could be pumped into the cylinder. At this point, the resistance heaters were turned on at low power to slowly heat the liquid to the starting point. The R-113 bulk temperature was usually raised close to the boiling point of 47.6°C . Water was only used in the LOCA simulation runs so the initial temperature was not as important due to the short drain time.

Once the temperatures for a given heater voltage stopped changing, the experimental run could begin. The computer program used to take the data from the thermocouples was started at the same time filming began.

The voltage on the variable current source controlling the heaters was changed to correspond to the desired heat flux after allowing some time to record the initial conditions. The pump was run in reverse to control the rate of coolant loss. The secondary drain line was also used when the pump speed was not adequate to drain the tank quickly enough for the desired drain time. Since we were interested in how the metal melts rather than the dynamics of a natural boiloff, using the pump is valid.

As the coolant recedes along the face of the Wood's metal, melting occurs where the R-113 or water is no longer providing adequate cooling. The process was videotaped, providing qualitative information about the nature of the flow. Data files containing the temperatures of the thermocouples as a function of time are also analyzed.

Chapter 2: Accident Scenarios

The two types of accidents which we tried to model with this experiment are the large loss of coolant accident (LOCA) and the complete loss of flow accident (LOFA). These accident sequences have been analyzed by EG&G for their Level 2 Probabilistic Risk Assessment of the ATR.

2.1 Large Loss of Coolant Accident

The base case LOCA, which was looked at by EG&G for the Level 2 PRA, is a 24 inch primary coolant outlet break which occurs while the core is at full power of 250 MW. [6, p.2-2] The SCDAP/RELAP5 computer code was used to model the primary coolant system response and core damage progression. [6, p.1-1]

In this sequence, the time between the pipe break and full relocation in one of the quadrants of the core is only 101.2 seconds. [6, p.2-6] Initial relocation begins at about

85 seconds. About 60 seconds into the transient, the pressure in the core is low enough that extensive boiling and fuel heatup begin. The flow of coolant is downward through the core so the boiling causes flow stagnation as the rising vapor hits the falling liquid. [6, p.2-25] The computer code gives the time sequence but does not indicate how the melting metal actually behaves.

2.1.1 Application of EG&G LOCA Analysis

The 24 inch LOCA event looked at by EG&G takes about 100 seconds from initiation to fuel relocation. Depending on the size of the LOCA, and the initial conditions of the reactor, this time could vary so we chose a range of time for our LOCA simulations. Using the pump and secondary drain line, we were able to vary the drain time of the coolant from 10 to 150 seconds. A longer time results in a boiloff type event with the melting fuel following the coolant as it recedes along the face of the Wood's metal.

2.2 Complete Loss of Flow Accident

Several ATR LOFA scenarios have been analyzed by EG&G using the SCDAP/RELAP5 computer code to model the primary coolant system and fuel behavior.[7, p.1] We looked at two sequences when designing the experiment, a high pressure core boiloff designated LCP15 for the PRA, and a low pressure core boiloff

sequence designated LPP9 for the PRA. We were most interested in the time sequence of the events to get an idea of what the experimental parameters should be.

The LCP15 event begins with a loss of commercial power which eventually leads to a high pressure core uncover and complete core meltdown, partially due to operator error. In this event, it takes 14.2 hours for the water level to fall completely and uncover the core. However, once the fuel melt begins, it takes about 4 minutes 12 seconds for the affected quadrant of the core to completely relocate. [7, p.22]

The LPP9 event begins with a failure of the ATR pressurizing system; all pumps fail. This results in low pressure core uncover. The entire scenario is 18.9 hours long, but the time from initial fuel heatup to the beginning of relocation is 10 minutes 12 seconds. [7, p.127] The calculation was ended when the entire core was at melting temperature, about 30 minutes from the initial fuel melting. It is not explicitly stated how long it takes for the first affected quadrant to completely relocate.

The SCDAP/RELAP5 computer code is effective at calculating the time sequences for the different accidents but we were more interested in the melting dynamics of the fuel, specifically how much the relocating fuel would block the flow of coolant. The code used by EG&G does not adequately model this.

2.2.1 Application of EG&G LOFA Analysis

The data from the EG&G Internal Technical Report on the LOFA was used to help define a time range for the draining of the coolant for the LOFA portion of our experiment. We wished to preserve the time from initial fuel melt to the subsequent relocation. This takes just over 4 minutes in the LCP15 event, and around 10 minutes for

the LPP9 scenario. We therefore varied the drain time of the coolant from 4 to 12 minutes for the boiloff runs.

Chapter 3: General Experimental Setup

This experiment went through several metamorphoses before the optimum setup was found. The vast majority of the time devoted to a project like this is spent on mechanical design, construction, and upkeep of the experimental apparatus. Section 3.1 discusses the original "final" design of the experiment. Sections 3.2 and 3.3 discuss the actual experiments done for the Nuclear Engineering thesis work.

3.1 Single Cast Plate

Originally the experiment was designed with a single box with heaters behind the cast Wood's metal. This box was immersed in the R-113 coolant and filmed as the coolant level receded through boiloff and pump action. This setup worked well for obtaining video output as well as qualitative observations during and after the run due to the open design.

Unfortunately, the original box was made out of phenolic which was not able to withstand the high temperatures which occur inside the resistance heater cavity. This apparatus burned during a trial run resulting in its complete destruction. This however turned out to be a good thing because the redesigned experiment incorporated many mechanical improvements such as better temperature instrumentation, improved Wood's metal casting ability, and most importantly, substantially higher temperature tolerance.

The aluminum assembly could have been run as a single plate experiment as well but since the ATR has parallel fuel plates, we decided the experiment should have parallel plates as well to mimic the actual conditions.

3.2 Parallel Heated Cast Plates

This part of the experiment most closely resembles the conditions in the ATR. Two identical aluminum boxes outfitted for resistance heaters were constructed. Each box has a milled depression for casting of the Wood's metal. They were set up in the glass tube separated by a small gap to simulate the closely spaced fuel plates in the core. Clearly this is the more realistic of the two experimental setups, however, it is harder to film the experimental runs due to the small gap between the plates.

Only one of the two plates is instrumented for temperature readings as shown in Figure 1-2. This is because of the symmetry between the two boxes. The voltage supplied to the two sets of resistance heaters is kept constant, so the heat flux is the same.

For more detailed information on this part of the experiment, reference "Fuel Melting and Relocation in the Advanced Test Reactor: Simulant Experiments in a Closed Geometry". [8]

3.3 Heated Cast Plate Parallel with Clear Wall

Although the experiment with parallel heated plates is perhaps closer to the physical characteristics of the ATR core, it is not possible to obtain a direct view of what is actually going on due to the small gap width between the plates. One can run the experiment with an increased gap width to improve the visualization capabilities, but then the ATR core may no longer be adequately modeled since the gap width between the fuel plates in the ATR is 2 mm.

This problem is partially solved by using a clear wall for one of the plates. The Wood's metal is cast onto one aluminum box and set up opposing a 1 cm thick transparent plastic plate. Although this wall cannot be heated, it can be a valuable model of the ATR core fuel plates. Since the gap can be made the same as in the ATR, the flowing molten metal will have the same physical route to follow. The rivulets which form are generally thinner than the gap width, so no contact is made with the other plate unless the molten metal flows into the coolant, as in the case of the boiloff sequence, and solidifies, gradually increasing the rivulet thickness. If the adjoining plate also had melting metal, there would be some interaction between the two faces which would result in different dynamics than the heated plate with plastic wall, but the interaction would be different every time due to the random formation of metal flow paths.

In the LOFA scenario experiment there is only half the convective cooling for a given coolant height, as compared to two heated plates, because the total heat flux being used to boil coolant is cut in half. Therefore the metal will heat up and melt more quickly than the case where both plates are heated. Neither design has the capability to melt the

metal while R-113 is still present in a particular location. In reality, this is also the case within the ATR, since melting does not occur in the accident scenarios while liquid coolant is still in contact with the fuel plates.

3.3.1 Determination of Experiment Parameters

The following criteria were used to decide what runs to do with the clear wall. First, since it was not possible to adequately view the dual heated wall runs, the clear plate was used for a couple of cases using similar conditions as a dual plate run to see what may have happened. Second, there were too many variables to run the experiment with every conceivable combination. Therefore, a spread of runs were designed using bounding conditions and several other middle combinations in an attempt to gain enough information given the limited amount of runs possible. The description of each run explains why that particular set of conditions was chosen.

The independent variables were the coolant type, gap width, heat flux, drain time, and initial coolant degree of subcooling. All LOFA simulations were done using R-113 as the coolant. Water was used for all but two of the LOCA simulations. The degree of subcooling and the heat flux were found to have an insignificant effect on the results in the range at which the runs were done. Explanations for this phenomenon are given in the following paragraphs.

Ideally we wanted to do the boiloff sequences using a variety of bulk temperatures to simulate a saturated or subcooled coolant. However, although the R-113 is initially subcooled, the bulk temperature quickly reaches 47.6°C. Also, even at saturation, the R-113 is 22.4°C less than the melting temperature of the Wood's metal. If subcooled by 10°

C, the effect is the same, the liquid metal solidifies upon dropping into the coolant. There is less vapor when the liquid is subcooled because some of the heat flux goes into raising the temperature to saturation, but in our initial tests of the experiment, we did not notice enough of a difference to warrant doing a full set of runs at different degrees of subcooling.

The heat flux does have an effect on the behavior of the experimental runs, but in our setup, the range of heat flux values we were able to use was not significant to the results. The heaters which we bought were the most powerful ones available for the given size, but due to the large amount of losses by conduction through the aluminum, the heat flux was lower than we would have liked. The lowest power we were able to use and still melt the metal in a timely fashion was 80% of the maximum, resulting in a small range of available heat flux values. Of the clear plate runs, only LOFA Run 2, discussed in §4.4, was done at the lower power setting, with no evident effect on the results.

We were left with the gap width and the drain time as the independent variables. As discussed in Chapter 2, the range of times for the LOCA runs was set at 10 to 150 seconds and the LOFA run drain times were varied from 4 to 12 minutes. Tables 3-1 and 3-2 attempt to illustrate how the range of parameter combinations was covered. The runs indicated in bold are the clear plate runs discussed here.

Table 3-1: Variable Combinations for LOCA Runs

	2 mm Plate Gap	4 mm Plate Gap	6 mm Plate Gap
Short Drain Time	LOCA 3, LOCA 5		LOCA 2
Long Drain Time	LOCA 4, LOCA 8	LOCA 6, LOCA 7	LOCA 1

Table 3-2: Variable Combinations for LOFA Runs

	2 mm Plate Gap	4 mm Plate Gap	6 mm Plate Gap
~4 min Drain Time			LOFA 3
~7 min Drain Time	LOFA 2, LOFA 7	LOFA 5, LOFA 6	
~10 min Drain Time	LOFA 1, LOFA 8		LOFA 4

The ATR fuel plates are separated by a 2 mm gap so more runs were done with a 2 mm gap at the expense of a more even spread of parameter combinations. Only one LOFA run was done at the shortest drain time because the LOCA runs showed the dynamics of shorter drain times, allowing us to explore what happens in the 7 to 12 minute range with the LOFA runs.

Table 3-3 shows the experimental runs which were done to simulate the LOCA, showing both the dual heated plate and the clear plate runs. This paper only discusses the clear plate runs. Table 3-4 shows the experimental runs done to simulate the LOFA, once again listing runs done by both apparatuses. The run numbering scheme used in the table will be used throughout this thesis.

Table 3-3: LOCA Runs

Run Number	Apparatus	Plate Gap [mm]	Coolant	Drain Time [sec]
1	Dual	6	R-113	120
2	Dual	6	Water	10
3	Clear	2	Water	13
4	Dual	2	Water	120
5	Dual	2	Water	10
6	Clear	4	R-113	155
7	Dual	4	Water	120
8	Clear	2	Water	85

Table 3-4: LOFA Runs

Run Number	Apparatus	Plate Gap [mm]	Coolant	Drain Time (Approx)
1	Dual	2	R-113	10 min
2	Clear	2	R-113	7 min
3	Dual	6	R-113	4 min
4	Clear	6	R-113	10 min
5	Dual	4	R-113	6 min
6	Clear	4	R-113	6 min
7	Dual	2	R-113	7 min
8	Clear	2	R-113	12 min

Chapter 4: Experimental Evidence

4.1 LOCA Experimental Run 3

Table 4-1: LOCA Run 3 Parameters

Experiment	Clear Plate on Heated Wall
Accident Type	LOCA
Coolant	Water
Initial Coolant Bulk Temperature	27.4°C
Gap Width	2 mm
Drain Time	13 seconds

4.1.1 Description

This run was done to model a loss of coolant accident. Using the pump at full power and the secondary drain line, the water was drained in 13 seconds after turning the heaters to full power. Initially, the heaters were set to 80% power to heat the plate to the initial temperatures shown in the temperature plot, Figure 4-1. To model the loss of coolant accident, the metal is initially heated up as close to melting temperature as possible so that upon loss of liquid coolant, the melting progresses quickly. At time zero, recording began. At 120 seconds the heaters were turned up to full power, the pump started, and the drain line opened. There is some initial heating of the metal since the system is not quite at steady state at time zero. The assembly is slightly tilted to help keep the Wood's metal attached to the face of the heated plate.

The temperature graph does not show the temperature readouts of thermocouples 3, 5 and 7 because they normally read the same as the thermocouples at the same height on the other side of the Wood's metal, 2, 4 and 6. This is done to reduce clutter on the graph. For the rest of the runs, the readings from locations 2, 4 and 6 will be plotted instead of 3, 5 and 7 but in this case, thermocouple number 3 malfunctioned as is evident in the Appendix temperature data so the other readings were used instead.

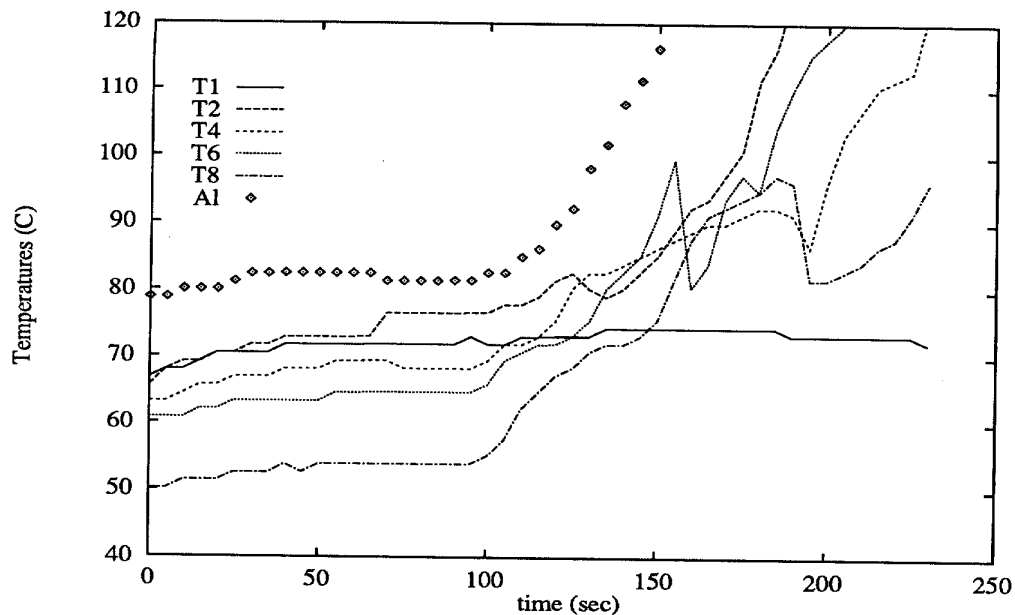


Figure 4-1: LOCA Run 3 Temperature Profiles

4.1.2 Results and Conclusions

As the heaters are used to heat the plate and the water, there is convective cooling along the face of the plate. This is not very evident on the tape due to the angle of the camera. This cooling is not very effective however, so even at the lower initial power, the plate temperature and bulk temperature of the water are increasing. There is an immediate temperature response once the heaters are turned to full power, especially when the metal is exposed to the air. This is quite evident on the temperature graph; the heater power was increased at 120 seconds, and the coolant drained shortly thereafter.

Thermocouple 1, which is highest up on the plate, reads an essentially constant 70° C over the entire run because at first it was immersed in the Wood's metal at its melting

temperature, then upon relocation of the Wood's metal, it was measuring the temperature of the air right next to the heated aluminum face.

The plot labeled A1 on Figure 4-1 is the temperature of the inside of the aluminum assembly as measured by thermocouple 9. This value was used for safety purposes during the run to keep the assembly from overheating.

There was some melting of the metal before the water was drained as is indicated by thermocouple 2. Once the water was gone, all of the face was above the melting point. At 1 min 50 sec into the run, the first drop is visible in the center of the plate. This drop quickly turns into a rivulet as liquid metal is fed to it. There is melting occurring at the entire upper half of the plate at the time, but the liquid only manifests itself at the starting point of the rivulet.

Initially it was difficult to heat the aluminum assembly up to the high initial temperature because a steep vertical temperature gradient was formed in the water, allowing the top of the Wood's metal to reach much higher temperatures than the bottom. This problem was solved by pumping in air through the bottom of the glass cylinder to mix the water and reduce the gradient.

The angle of plate tilt was small (about 5° off vertical) so large sections of the face were still able to fall off. We could have increased the amount of plate tilt, but we were trying to mimic the ATR structure as closely as possible. Before the metal began breaking off, it was evident how the melt progresses under these conditions.

The view on tape of this experimental run is obscured by water vapor which formed on the inside of the plastic wall, and on the inside of the viewport. The next LOCA simulation done with the clear plate used R-113 as the coolant to end the water vapor effects.

The gap width was set to 2 mm which is about the same as the ATR fuel plate gap. The width did not have much of an effect on the melting though since the rivers which formed were so thin.

At the bottom of the plate, there is a small lip between the cast metal and the center gap. This lip is less than 1 mm thick but does partially block the flow of the liquid metal, causing a backup at the bottom. Surprisingly, the metal tends to back up for a couple of centimeters, in this case about 2 cm, instead of eventually melting completely and sliding out. The structure of this remaining metal is fibrous, much less dense than the regular solid form of the Wood's metal. As one can see on the temperature profile, all plate temperatures are higher than the melting temperature. Given more time, this metal would have remelted and slid out of the gap, but due to a lack of cooling, the apparatus would have ended up well above our safety limit of 200°C so the run was ended.

4.2 LOCA Experimental Run 6

Table 4-2: LOCA Run 6 Parameters

Experiment	Clear Plate on Heated Wall
Accident Type	LOCA
Coolant	R-113
Initial Coolant Bulk Temperature	28.2°C
Gap Width	4 mm
Drain Time	155 seconds

4.2.1 Description

This is the second of the clear plate runs done to model the LOCA. R-113 was used as the coolant to avoid water vapor effects which degraded the view clarity of Run 3. A gap width of 4 mm was used. The initial plate temperatures were less than 47.6°C, the boiling temperature of the refrigerant.

To begin the run, the resistance heaters were used at low power to heat the plate and coolant. When the plate temperatures reached into the 40 to 50 degree Celsius range, the camera was turned on. When the recording began, the temperature recording program was started at time zero. For the first 30 seconds the heaters were at 80% power. At 30 seconds, the heaters were turned up to full power without yet beginning the draining of the coolant. This was done to get the plate temperature as high as possible before beginning the drain process. After 90 more seconds, the pump was turned on at full power and the secondary drain line opened to begin the fast but controlled drain process.

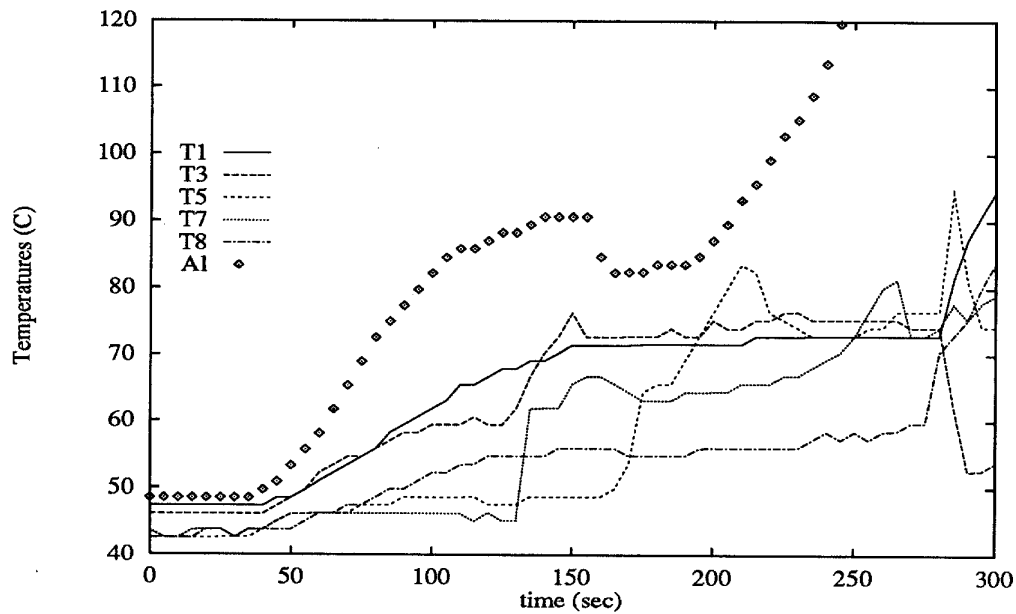


Figure 4-2: LOCA Run 6 Temperature Profiles

4.2.2 Results and Conclusions

Since R-113 was used as the coolant, the plate was only able to be easily heated to 47.6°C, which is well below the 70°C melting temperature of the Wood's metal. This is why the heaters were turned to full power before beginning the draining of the coolant. There is some thermal inertia of the aluminum block so the temperature of the plate was increased to 70°C more quickly by turning the heaters to full power early. Due to the thermal gradient in the R-113, the upper part of the plate was warmer initially than the lower half as can be seen in Figure 4-2.

The initial conditions resulted in some boiling of the R-113 on the face of the plate. This boiling is quite effective at heat transfer which is why the face cannot be heated above

the boiling temperature of the refrigerant. However, by turning the heaters to full power before draining, the temperature of the face shot above the melting point almost immediately after being uncovered. This resulted in liquid metal dripping into the coolant before it was completely drained. At 2 min 17 sec the first drips were visible at the top of the plate. These drops turned into a rivulet right away. At 3 min 10 sec, the first rivulet flowed to the lower half of the plate where it solidified, increasing the thickness of the Wood's metal there to the point where it pressed against the plastic plate. Since the liquid flows in rivers down the exposed part of the plate, the thickness is increased in small areas where the rivers flow into the coolant. In this way, this run acted like a cross between the boiloff event and the loss of coolant event.

The rivers of metal increased in thickness near the bottom of the plate as the run progressed since the metal was solidifying as it dripped into the R-113. Some of the solid rivers were greater than the 4 mm gap thickness and could be seen pushing up against the plastic wall. If the refrigerant had been drained any more slowly in Run 6, there may have been more blockage in the gap due to liquid metal solidification as it hit the coolant.

This run resulted in some backup of Wood's metal at the bottom of the assembly as happened in Run 3. The same lightweight structure formed at the bottom as happened in LOCA Run 3. Some relatively large pieces of the metal also broke off and fell against the plastic at 4 min 10 sec, however, the behavior of the molten metal interacting with the coolant is clear before this happens. At 5 min 15 sec, a large amount of metal slumps down at once. This is not representative of what would happen since the effect was caused by the large chunks of metal which had broken off and fallen into the lower region of the plate.

4.3 LOCA Experimental Run 8

Table 4-3: LOCA Run 8 Parameters

Experiment	Clear Plate on Heated Wall
Accident Type	LOCA
Coolant	Water
Initial Coolant Bulk Temperature	24.4°C
Gap Width	2 mm
Drain Time	85 seconds

4.3.1 Description

Although using the R-113 as the coolant in the LOCA runs results in a better film of the event due to the elimination of fogging effects, water was used again in this run so that the plates could be heated up closer to the melting temperature of the Wood's metal before draining the coolant. The heaters were initially set to 80% power to heat up the aluminum assembly and Wood's metal. The first 30 seconds of data collection and filming are at the initial power level to set the initial conditions. At 30 seconds into the run, the heaters were turned to full power, the pump turned to full power, and the drain line opened. The coolant reached the bottom of the Wood's metal in 85 seconds.

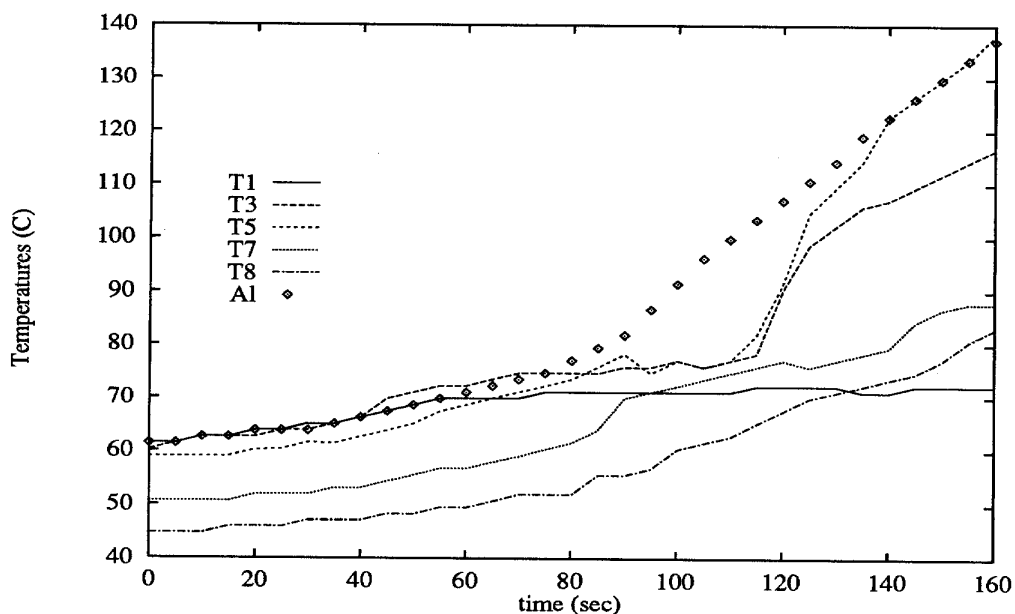


Figure 4-3: LOCA Run 8 Temperature Profiles

4.3.2 Results and Conclusions

Melting of the metal was apparent 1 min 15 sec into the run, when the water level was half way down the plate. As happened in one of the LOFA simulations, one major river formed in the center of the plate, fed by tributaries at the top of the plate. While the coolant was still present, this river extended into the water for several centimeters. The thickness of this river increased as molten Wood's metal, which had been present for more than a couple of seconds in the water, solidified and the still flowing liquid metal piled up on the solid part. By 1 min 13 sec, the gap was crossed and the metal pressed against the clear wall. The flow of metal soon had to find new paths due to this complete obstruction.

The temperature plot, Figure 4-3 indicates that this was one of the best Wood's metal casting jobs. It is clear from the profiles exactly what happened on the plate. Due to the slower drain time, the upper half of the plate has the chance to heat up above the melting temperature of the Wood's metal before the bottom half.

At 1 min 52 sec, some relatively large pieces of metal broke off and fell into the lower half of the apparatus. This signaled the end of the ability to glean any more information from this particular experimental run.

4.4 LOFA Experimental Run 2

Table 4-4: LOFA Run 2 Parameters

Experiment	Clear Plate on Heated Wall
Accident Type	LOFA
Coolant	R-113
Initial Coolant Bulk Temperature	39.0°C
Gap Width	2 mm
Drain Time	6 min 25 sec

4.4.1 Description

This was the first of the LOFA runs done using the clear plate apparatus. The drain time was designed to be 7 minutes but the pump speed is somewhat variable even at constant controller settings so the final time was a bit off. LOFA run number 1 was done using two heated plates with a 2 mm gap. This run was made to get a better idea of what happened between the plates.

Initially the power of the heaters was set to 20% in order to increase the coolant bulk temperature without boiling much of the R-113. The first 30 seconds of taping shows the initial conditions at the 20% power level. See Figure 4-4 for the temperature profiles. The heaters were then turned to 80% power which is the lower of the two power levels used in our experimental runs. The pump was not started until 400 seconds into the run. The delay was used to allow the metal to heat up and begin the boiling process before draining the cylinder. This ensures that the experiment more closely models what would actually happen in the ATR upon a loss of flow.

The pump speed was set at 5.5 which was intended to drain the coolant in 7 minutes. The actual drain time was 6 minutes and 25 seconds which worked fine for our purposes.

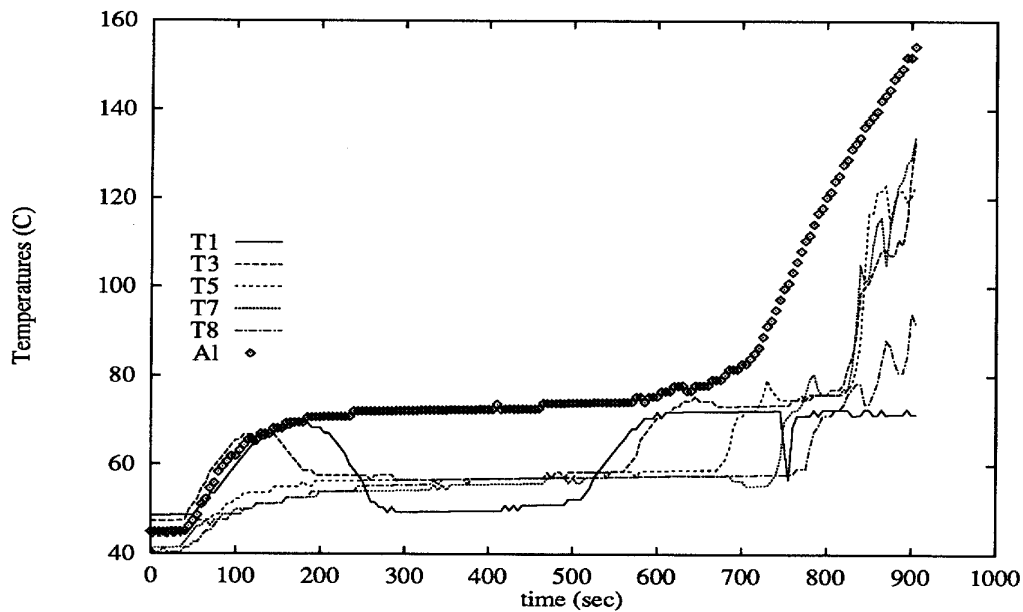


Figure 4-4: LOFA Run 2 Temperature Profiles

4.4.2 Results and Conclusions

Figure 4-4 gives a good indication of the progression of the coolant down the plate. While liquid R-113 is still in contact with the Wood's metal, the temperature stays well below the melting temperature. As the coolant is drained, one by one the thermocouples show the metal increasing to the melting point when the coolant disappears.

This run demonstrated quite well the flow dynamics of the liquid metal. The turbulent boiling of the R-113 sets up an 8 to 10 cm two phase region above the bulk liquid height which is quite effective at cooling the metal. The Wood's metal therefore did

not melt until this region fell below it, which did not occur until the coolant was about 2/3 of the way down the plate. At 10 min 44 sec the first drips formed and began rolling down the plate. These turned into rivulets by 10 min 59 sec.

This run provided perhaps the best example of how the molten metal flows down the face of the plate. The rivulets which originate in the areas where only air is in contact with the face of the plate flow into the two phase region and begin to solidify. The rivulets therefore get thicker as more metal flows into the area where solidification is taking place. The gap in this run was only 2 mm so the metal quickly began pushing up against the plastic and spreading out. At 11 min 40 sec, the gap had been crossed. The flow into some of the areas of solidification branches out to form new rivers to carry the flow of the Wood's metal. The end of the rivers follow the receding turbulent region.

At 14 min 20 sec, after the R-113 had been completely drained, the metal again slumped to the bottom of the plate as happened in the LOCA runs. This effect occurs due to an insufficient bond between the Wood's metal and aluminum block.

4.5 LOFA Experimental Run 4

Table 4-5: LOFA Run 4 Parameters

Experiment	Clear Plate on Heated Wall
Accident Type	LOFA
Coolant	R-113
Initial Coolant Bulk Temperature	45.9°C

Gap Width	6 mm
Drain Time	9 min 40 sec

4.5.1 Description

This run was done at the largest gap width, 6 mm. Although this gap is three times bigger than the gap between ATR fuel plates, dual heated plate runs were made using this thickness to improve the view of the camera. A clear plate run was made to see if the melting characteristics change much.

Due to the turbulent region above the bulk coolant level, no metal melts until the coolant level is low enough that only air is in contact with the Wood's metal. Since we lose some inventory of R-113 while running the boiloff events through small leaks in our system, it was decided to begin with the coolant at the height at which melting begins in order to conserve R-113 inventory. This would not have been much of an issue 10 years ago, but in 1995 it becomes illegal to buy R-113 so the current price has become excessive, about \$1100 for a 15 gallon drum, the smallest size it is sold in.

Initially the heaters were set to 40% power to slowly heat the bulk R-113 temperature up to saturation. Filming and data recording began when the temperature was close enough to 47.6°C. 30 seconds into the run, the heaters were turned to full power. At 120 seconds the pump was started at a speed of 5 on the controller. This resulted in an adjusted (for the 70% initial height) drain time of 9 min 40 sec.

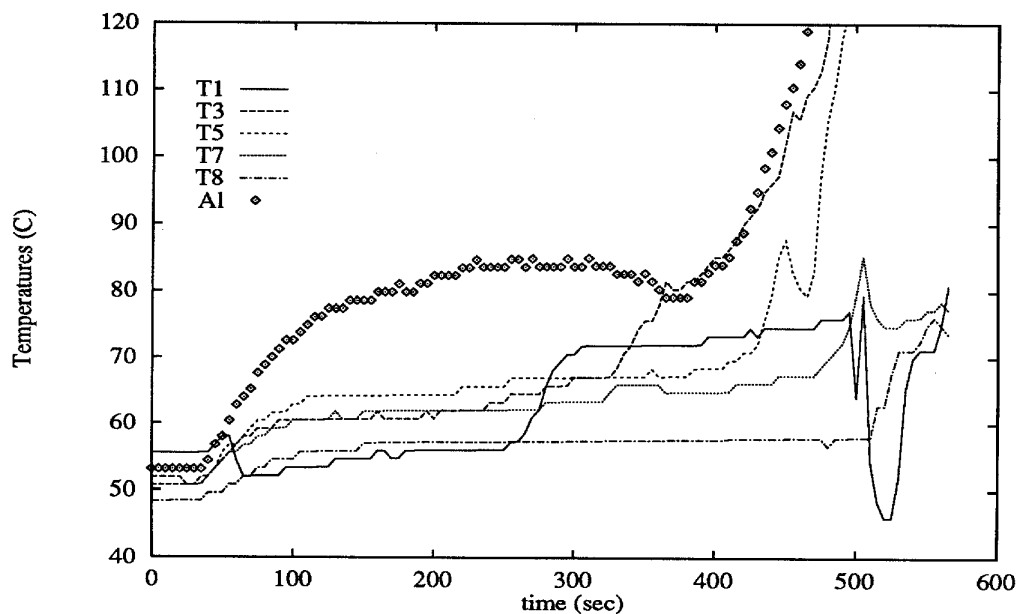


Figure 4-5: LOFA Run 4 Temperature Profiles

4.5.2 Results and Conclusions

Using the lower power at the beginning of the run, then turning up the heaters illustrates the development of the turbulent region above the coolant. The higher power setting was quite evident in the amount of turbulence.

At 5 min 35 sec, the first drips were visible along the side of the plate and, shortly thereafter, all over the top of the Wood's metal. By 6 min, the usual rivulets had formed and were flowing into the coolant turbulent region and solidifying. With the larger gap, the rivulets did not make much contact with the opposing plastic wall. The shape of the turbulent region, higher in the center, actually caused some of the molten metal to flow out the side gap rather than out the bottom.

A major portion of metal began to lose grip on the aluminum block and slump downward at 8 min 15 sec. The results of the run were already clear however. Due to the large gap width, this was not one of the more interesting runs. Not only are the physical dimensions getting a bit far from the actual ATR parameters, there is not much interaction between the clear wall and the flowing Wood's metal.

The temperature profile indicates that as soon as the R-113 turbulent layer was not in contact with the Wood's metal, it quickly melted and relocated. This is evident because the temperatures do not flatten out at 70°C once the temperatures begin increasing (see T3 and T5 plots on Figure 4-5).

It can also be noted from the temperature profile that it is not the height of the liquid which determines the time of melt because the turbulent layer above the top of the coolant effectively cools the metal until it too recedes.

4.6 LOFA Experimental Run 6

Table 4-6: LOFA Run 6 Parameters

Experiment	Clear Plate on Heated Wall
Accident Type	LOFA
Coolant	R-113
Initial Coolant Bulk Temperature	45.8°C
Gap Width	4 mm
Drain Time	6 min 20 sec

4.6.1 Description

The heaters were used at low power to heat the R-113 up to saturation temperature. The first 30 seconds of taping and data collection show the initial conditions. At 30 seconds into the run, the heaters were turned to full power and coolant inventory reduction started. The desired drain time for this run was 3 minutes. In order to accomplish this, the pump was turned to setting 4 and the drain line was opened. The resultant time to drain to the bottom of the assembly was 3 minutes 10 seconds. The R-113 was initially pumped half way up the plate so the adjusted drain time is 6 min 20 sec.

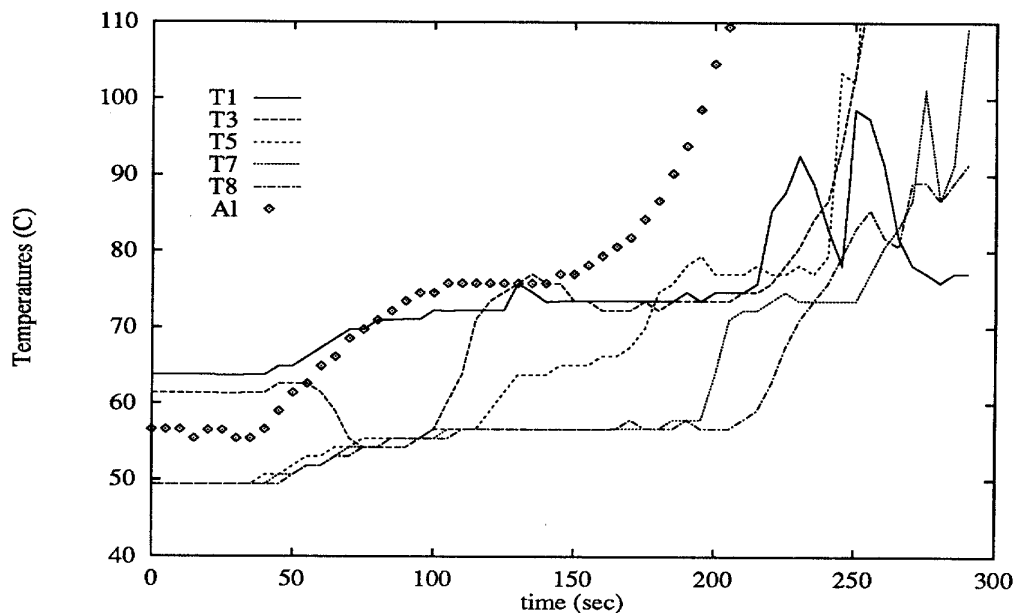


Figure 4-6: LOFA Run 6 Temperature Profiles

4.6.2 Results and Conclusions

By starting with the top of the coolant lower down on the plate, the development of the turbulent region above the liquid level could be seen. While the heaters were at the initial low power, the region extended upward about 1 cm. When the heaters were turned to full power at 30 seconds into the run, the region quickly extended upward 4 to 6 cm.

At 1 min 44 sec, the first melting of metal was evident over most of the top half of the plate. Drops were formed and turned into rivulets by 2 min 10 sec.

The rivulets of molten Wood's metal form in a different pattern each time. In this case, the rivulets at the top of the plate all flowed downward to form one large river in the center of the plate. This river acted as usual, following the receding R-113 and bumping up against the plastic barrier across the 4 mm gap by 3 minutes into the run.

The drain time does not seem to make much of a difference. The metal melts quickly enough to follow the R-113 downward. The drain time only made a difference in the quicker LOCA simulations.

The temperature graph shows the progression of melting of the Wood's metal which is helpful if the videotape of the experimental run is not readily available.

4.7 LOFA Experimental Run 8

Table 4-7: LOFA Run 8 Parameters

Experiment	Clear Plate on Heated Wall
Accident Type	LOFA
Coolant	R-113
Initial Coolant Bulk Temperature	42.2°C
Gap Width	2 mm
Drain Time	12 min 50 sec

4.7.1 Description

As in LOFA Run 6, the experiment was started with the R-113 filled to the half way point on the plate. The heaters were used at 40% power to heat the coolant to the bulk temperature of 42.2°C then turned to full power 30 seconds into the run. The long drain time was accomplished by setting the pump to a controller speed of 4, reducing the R-113 level at a rate of about 0.26 mm/sec, draining the coolant in 6 minutes 25 seconds which results in an adjusted drain time of 12 min 50 sec.

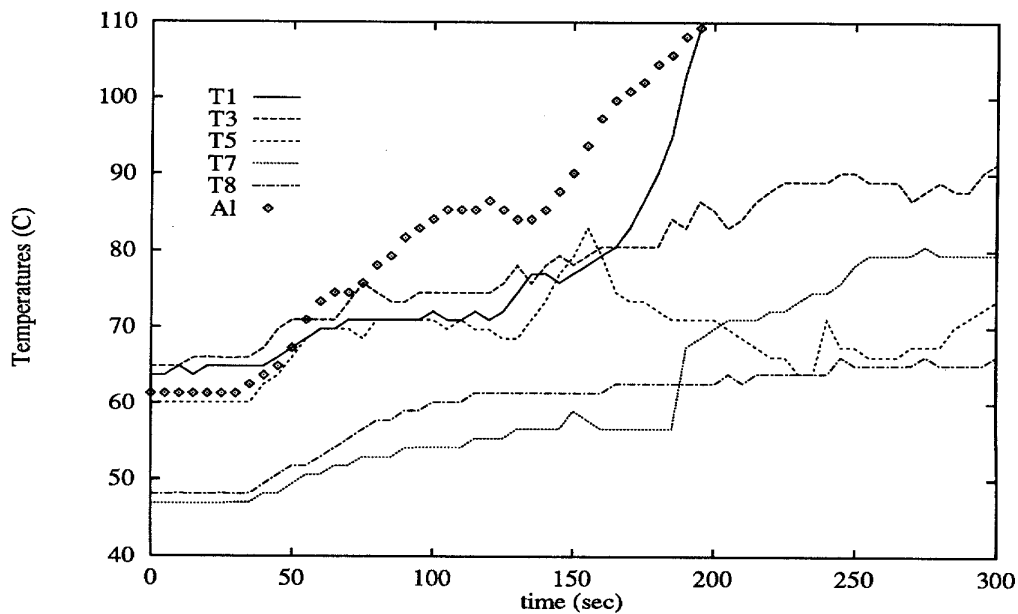


Figure 4-7: LOFA Run 8 Temperature Profiles

4.7.2 Results and Conclusions

There is not much new to be said for this run which has not been seen before in the previous runs. At 1 min 15 sec, the first drips were visible. The rivulets formed by 1 min 25 sec. The rivulets of liquid Wood's metal flowed into the R-113 turbulent upper area and solidified. Due to the small gap width, the rivulets pressed up against the plastic wall as they solidified and became thicker due to the backup. The gap was crossed in the turbulent area 1 min 40 sec into the run. It is clear that the small gap has quite an effect as there is much contact between the metal and the clear wall.

In this case, an entire network of rivulets formed which greatly reduced the flow area between the two plates. It would seem that more rivulets form when the gap is

smaller since the blockages do not hold as much metal, creating the need for more flow paths. This would be seen in the ATR core since the metal inventory is much greater but the gap width is still 2 mm. However, although the flow area between the plates is small near the end of the run, coolant would still have been able to flow between the plates, following a tortuous path through the rivulets.

Chapter 5: Videotape Notes

The following are some notes on the videotape recordings of the clear plate experimental runs. This chapter is only relevant to someone who is watching the tape. These are simply observations which would not have made sense in Chapter 4 to someone who had not seen the taped runs.

5.1 LOCA Experimental Run 3

This run was done using water as the coolant. One can see that there is a fogging problem when the water is drained. Water vapor forms both on the viewport surface and on the interior of the plastic plate opposing the heated wall. We designed a system to create better air circulation inside of the tube when using water as the coolant by attaching an air suction tube to the top of the glass test cylinder and opening up the top port completely as a result of these problems.

The drain time is defined as the time for the coolant to drain from the top to the bottom of the Wood's metal surface. The pump will be heard operating on the tape for a longer period because there is a volume at the bottom of the glass cylinder which must also be emptied after the coolant has fallen below the aluminum assembly.

5.2 LOCA Experimental Run 6

This run was done using R-113 as the coolant in an effort to avoid the fogging problems with much success. The air circulation system alleviated the fog on the viewport, making it possible to view the dual heated plate runs, but the vapor still formed on the inside of the clear plate. The clarity of the film is also improved due to better focusing.

5.3 LOCA Experimental Run 8

Water was used as the coolant so the fog problem comes up again as soon as the water level falls.

5.4 LOFA Experimental Run 2

The beginning of the film shows the initial conditions with the heaters at low power. One can see a small amount of boiling along the face of the metal. The line running down the center of the plate is the bundle of thermocouple wires which were difficult to keep submerged when casting the thin layer of Wood's metal. This did not seem to affect the run. This tape shows the turbulent region just above the coolant bulk level quite well, the film is a good demonstration of how the melting metal interacts with this region.

5.5 LOFA Experimental Run 4

At the beginning of the run, one can see that the two phase region only extends for about 1 cm at the low power setting. When the heat is turned up, this region quickly increases in length to the usual 8 to 10 cm. The R-113 is dirty which makes it difficult to film through. This problem is a result of corrosion from the inside of the copper condenser tube and bits of the gasket between the back plate and the aluminum box getting into the coolant. The problem is reduced by filtering the R-113, but this can not be done often since a fair amount of the refrigerant is lost to the atmosphere every time this is done.

5.6 LOFA Experimental Run 6

Much of the melting process is not very apparent on the tape of this run. The tributaries to the large river of molten metal in the center of the plate are very shallow. The camera does not pick these up well.

We had a problem with the condenser in this run which caused back flow of R-113 back into the glass tank. This is apparent in the later stages of the run, liquid is seen splashing down the face of the aluminum assembly. The effect was caused by too great of a pressure buildup in the R-113 reservoir, driven by the coolant pump running in reverse to drain the tank.

5.7 LOFA Experimental Run 8

The thermocouple bundle of wires is quite visible running down the center of the plate. This is one of the better boiloff demonstrations until the large chunks of Wood's metal fall off and choke off most of the coolant flow disrupting the progress of the experiment.

Chapter 6: Conclusions

6.1 General Notes

The intent of this experiment was to simulate the flow dynamics of melting fuel in the ATR. Although we could not use the actual ATR materials due to the high temperatures which would be involved, we believe the Wood's metal and R-113 performed in a similar fashion in the areas which we were interested in. The main result of this effort is the videotape of the experimental runs. The more quantitative data which could have been looked at such as heat transfer coefficients and temperature profiles of the coolant vapor would not have been of much use due to the differences in the materials properties between the experimental apparatus and the ATR core. Even the temperature data which was recorded was used more to define initial conditions and monitor the progress of the experimental runs rather than to form conclusions.

It is clear from viewing the experiments in progress and watching the videotape that as the metal melts, it flows along defined rivulets. This is important because the rivers

of metal will most likely not block the flow of the coolant or be blocked by solidified obstructions. It would be difficult to program the behavior of the melting fuel into an accident modeling program because of the somewhat random behavior of the relocation process.

It is difficult to say whether the behavior noted in this experiment would also hold for the ATR fuel plates because there are other considerations for fuel plates of the size found in the ATR core. Since the fuel plates themselves are providing structural support in the core, there may be a loss of structural integrity before melting of the sort found in this experiment. Also, the chunks of metal which fell from the top of the cast Wood's metal in our runs may be indicative of what would happen in some parts of the ATR core as relocation progresses.

6.2 Experimental Notes

The experimental apparatus used for this work was designed to do four things; vary the heat flux used to melt the simulated fuel, control the coolant level using the pump and secondary drain line, vary the gap between the two plates, and track the temperatures of the Wood's metal, aluminum box, and liquid coolant.

The sequence of experimental runs which we did was designed to cover all conditions through a combination of clear plate and dual heated plate runs. Since there were too many variables to do every possible combination of parameters, runs were chosen to look at the bounding conditions and cover the range of intermediate conditions. This paper only discusses the clear plate runs, for a full analysis see "Fuel Melting and

Relocation in the Advanced Test Reactor: Simulant Experiments in a Closed Geometry" [8] which looks at the dual heated plate experiment.

The temperature readings of the thermocouples must be considered qualitatively due to their uncertain location. For example, the end of the thermocouple could be quite close to the face of the aluminum face causing a higher reading. On the other hand, the thermocouples sometimes ended up reading the temperature of the surrounding air once the Wood's metal started relocating.

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Appendix (Temperature Data)

The appendix contains a printout of the temperature data files from the clear plate experimental runs discussed in this paper. The last column of data is from thermocouple 10 which measured the bulk temperature of the coolant. This was used to mark the initial temperature but was not plotted with the other data. The thermocouple was located in the coolant at about the middle of the vertical distance of the plate. Therefore, when the coolant was over half way drained, the wire was no longer in the liquid, making further measurements invalid.

LOCA 3 Temperature Data (Time in Seconds, Temperatures in °C)

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
0.0	66.8	65.6	25.0	63.2	70.4	60.8	63.2	50.1	78.8	27.4
5.0	68.0	68.0	25.0	63.2	70.4	60.8	64.4	50.1	78.8	27.4
10.0	68.0	69.2	25.0	64.4	70.4	60.8	64.4	51.3	80.0	27.4
15.0	69.3	69.2	25.0	65.7	70.4	62.1	64.5	51.3	80.0	27.5
20.0	70.5	70.5	25.1	65.7	71.7	62.1	64.5	51.3	80.0	27.5
25.0	70.5	70.5	25.1	66.9	71.7	63.3	65.7	52.5	81.2	27.5
30.0	70.5	71.7	25.1	66.9	71.7	63.3	65.7	52.5	82.4	27.5
35.0	70.5	71.7	25.1	66.9	72.9	63.3	65.7	52.5	82.4	27.5
40.0	71.7	72.9	25.1	68.1	72.9	63.3	66.9	53.8	82.5	27.5
45.0	71.7	72.9	25.1	68.1	72.9	63.3	66.9	52.6	82.5	27.5
50.0	71.7	72.9	25.1	68.1	72.9	63.3	66.9	53.8	82.5	27.5
55.0	71.7	72.9	25.1	69.3	72.9	64.5	66.9	53.8	82.5	27.5
60.0	71.7	72.9	25.1	69.3	72.9	64.5	66.9	53.8	82.5	27.5
65.0	71.8	73.0	25.2	69.4	73.0	64.6	67.0	53.8	82.5	27.5
70.0	71.8	76.5	25.2	69.4	73.0	64.6	67.0	53.8	81.3	27.6
75.0	71.8	76.5	25.2	68.2	73.0	64.6	67.0	53.8	81.3	27.6
80.0	71.8	76.5	25.2	68.2	73.0	64.6	67.0	53.8	81.3	27.6
85.0	71.8	76.5	25.2	68.2	73.0	64.6	67.0	53.8	81.3	27.6
90.0	71.8	76.5	25.2	68.2	73.0	64.6	67.0	53.8	81.4	27.6
95.0	73.0	76.6	25.2	68.2	73.0	64.6	67.0	53.9	81.4	27.6
100.0	71.8	76.6	25.2	69.4	74.2	65.8	69.4	55.1	82.6	30.0
105.0	71.8	77.8	25.2	71.8	75.4	69.4	71.8	57.5	82.6	36.0
110.0	73.0	77.8	25.2	71.8	76.6	70.6	74.2	62.2	85.0	27.6
115.0	73.0	79.0	25.3	73.0	77.8	71.8	75.4	64.6	86.2	26.5
120.0	73.1	81.4	25.3	75.4	81.4	71.9	76.6	67.1	89.8	27.7
125.0	73.1	82.6	25.3	80.2	82.6	73.1	79.0	68.3	92.2	27.7
130.0	73.1	80.2	25.3	82.6	81.4	75.4	83.8	70.7	98.2	27.7
135.0	74.3	79.0	25.3	82.6	81.4	80.2	91.0	71.9	101.8	27.7
140.0	74.3	80.2	25.3	83.8	82.6	82.7	95.9	71.9	107.9	27.7
145.0	74.3	82.7	25.3	85.1	83.9	85.1	97.1	73.1	111.5	27.7
150.0	74.3	85.1	25.3	86.3	86.3	91.1	98.3	75.5	116.3	27.7
155.0	74.3	88.7	25.3	87.5	89.9	99.5	95.9	81.5	121.1	28.9
160.0	74.3	92.3	25.3	88.7	109.1	80.3	95.9	87.5	125.9	28.9
165.0	74.3	93.5	25.4	89.9	115.1	83.9	95.9	91.1	129.6	29.0
170.0	74.3	97.1	25.4	89.9	119.9	93.5	97.1	92.3	133.2	29.0
175.0	74.3	100.7	25.4	91.1	123.5	97.1	98.3	93.5	136.8	29.0
180.0	74.3	111.5	25.4	92.3	128.4	94.7	98.3	94.7	140.4	29.0
185.0	74.3	116.3	25.4	92.3	132.0	104.3	100.7	97.1	144.0	30.1

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
190.0	73.2	126.0	25.4	91.2	138.0	110.3	104.4	96.0	147.7	29.0
195.0	73.2	141.6	25.4	86.4	138.0	115.2	106.8	81.6	150.1	30.2
200.0	73.2	146.5	25.4	96.0	144.0	117.6	108.0	81.6	154.9	30.2
205.0	73.2	150.1	25.4	103.2	150.1	120.0	109.2	82.8	157.3	30.2
210.0	73.2	152.5	25.4	106.8	153.7	122.4	115.2	84.0	159.7	30.2
215.0	73.2	154.9	25.4	110.4	156.1	123.6	118.8	86.4	163.3	30.2
220.0	73.2	158.6	25.5	111.6	157.4	126.0	122.4	87.6	165.8	30.2
225.0	73.2	161.0	25.5	112.8	159.8	129.7	127.2	91.2	168.2	31.4
230.0	72.1	162.2	25.5	122.4	164.6	127.2	110.4	96.0	170.6	30.2

LOCA 6 Temperature Data (Time in Seconds, Temperatures in °C)

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
0.0	47.3	44.9	46.1	42.5	42.5	41.3	43.7	42.5	48.5	28.2
5.0	47.3	44.9	46.1	42.5	42.5	40.1	42.5	42.5	48.5	28.2
10.0	47.3	44.9	46.1	42.5	42.5	40.1	42.5	42.5	48.5	28.2
15.0	47.3	44.9	46.1	42.5	42.5	40.1	43.7	42.5	48.5	28.2
20.0	47.3	44.9	46.1	42.5	42.5	41.3	43.8	43.8	48.5	28.2
25.0	47.3	45.0	46.1	42.6	42.6	41.4	43.8	43.8	48.5	28.2
30.0	47.3	45.0	46.1	42.6	42.6	41.4	42.6	42.6	48.5	27.1
35.0	47.3	45.0	46.1	42.6	42.6	41.4	43.8	43.8	48.5	28.2
40.0	47.3	45.0	46.1	42.6	43.8	41.4	43.8	43.8	49.7	28.2
45.0	48.5	45.0	47.3	43.8	45.0	42.6	45.0	43.8	50.9	28.2
50.0	48.5	46.1	48.5	43.8	46.1	42.6	46.1	43.8	53.3	27.1
55.0	49.7	46.1	49.7	43.8	46.1	43.8	46.1	45.0	55.7	27.1
60.0	51.0	46.2	52.2	43.8	46.2	42.6	46.2	46.2	58.1	28.3
65.0	52.2	46.2	53.4	43.8	46.2	43.8	46.2	46.2	61.7	28.3
70.0	53.4	46.2	54.6	43.8	46.2	42.6	46.2	47.4	65.3	28.3
75.0	54.6	46.2	54.6	43.8	47.4	42.6	46.2	47.4	68.9	28.3
80.0	55.8	47.4	55.8	43.9	47.4	42.6	46.2	48.6	72.5	28.3
85.0	58.2	48.6	57.0	43.9	47.4	42.7	46.2	49.8	74.9	28.3
90.0	59.4	49.8	58.2	43.9	48.6	43.9	46.2	49.8	77.3	29.5
95.0	60.6	49.8	58.2	43.9	48.6	43.9	46.2	51.0	79.7	28.3
100.0	61.8	51.0	59.4	43.9	48.6	45.0	46.2	52.2	82.1	29.5
105.0	63.0	51.0	59.4	43.9	48.6	43.9	46.2	52.2	84.5	29.5
110.0	65.4	51.0	59.4	43.9	48.6	45.0	46.2	53.4	85.8	29.5
115.0	65.4	52.3	60.6	43.9	48.7	45.1	45.0	53.5	85.8	29.6
120.0	66.6	52.3	59.4	43.9	47.5	45.1	46.3	54.7	87.0	30.8
125.0	67.8	52.3	59.4	43.9	47.5	43.9	45.1	54.7	88.2	30.8
130.0	67.8	54.7	61.8	42.7	47.5	43.9	45.1	54.7	88.2	30.8
135.0	69.0	60.6	66.6	42.7	48.7	46.3	61.8	54.7	89.4	30.8
140.0	69.0	66.7	70.2	42.7	48.7	46.3	61.9	54.7	90.6	32.0
145.0	70.2	70.2	72.6	42.8	48.7	46.3	61.9	55.9	90.6	32.0
150.0	71.4	71.4	76.2	44.0	48.7	46.3	65.5	55.9	90.6	33.2
155.0	71.4	72.6	72.6	44.0	48.7	46.3	66.7	55.9	90.6	34.4
160.0	71.4	72.6	72.6	44.0	48.7	48.7	66.7	55.9	84.6	34.4
165.0	71.4	72.6	72.6	47.5	49.9	47.5	65.5	55.9	82.2	35.6
170.0	71.4	72.6	72.7	51.1	53.6	47.6	64.3	54.8	82.3	35.6
175.0	71.5	72.7	72.7	51.2	64.3	47.6	63.1	54.8	82.3	36.8
180.0	71.5	72.7	72.7	52.4	65.5	47.6	63.1	54.8	83.5	36.8
185.0	71.5	72.7	73.9	52.4	65.5	47.6	63.1	54.8	83.5	36.8

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
190.0	71.5	72.7	72.7	55.9	69.1	47.6	64.3	54.8	83.5	36.8
195.0	71.5	72.7	72.7	69.1	72.7	48.8	64.3	55.9	84.7	35.6
200.0	71.5	72.7	75.1	71.5	76.3	48.8	64.4	56.0	87.1	16.6
205.0	71.5	73.9	73.9	71.5	79.9	48.8	64.4	56.0	89.5	19.0
210.0	71.5	73.9	73.9	78.7	83.5	48.8	65.6	56.0	93.1	23.8
215.0	72.7	73.9	75.1	83.5	82.3	48.8	65.6	56.0	95.5	26.2
220.0	72.7	73.9	75.1	78.7	76.3	48.8	65.6	56.0	99.1	29.7
225.0	72.7	75.1	76.3	75.1	75.1	48.8	66.8	56.0	102.7	29.7
230.0	72.7	76.3	76.4	75.1	74.0	48.8	66.8	56.0	105.1	29.7
235.0	72.8	77.6	75.2	74.0	72.8	48.9	68.0	57.2	108.7	29.8
240.0	72.8	77.6	75.2	74.0	72.8	48.9	69.2	58.4	113.6	29.8
245.0	72.8	78.8	75.2	75.2	72.8	65.6	70.4	57.2	119.6	29.8
250.0	72.8	80.0	75.2	84.8	72.8	54.8	72.8	58.4	124.4	29.8
255.0	72.8	83.6	75.2	107.6	74.0	71.6	76.4	57.2	128.0	29.8
260.0	72.8	87.2	75.2	117.2	74.0	72.8	80.0	58.4	131.6	29.8
265.0	72.8	90.8	75.2	123.2	76.4	86.0	81.2	58.5	136.5	29.8
270.0	72.8	98.0	74.0	126.8	76.4	80.0	72.8	59.7	141.3	29.8
275.0	72.8	117.2	74.0	129.2	76.4	78.8	72.8	59.7	144.9	31.0
280.0	72.8	132.8	74.0	135.3	76.4	82.4	74.0	70.4	148.5	31.0
285.0	81.2	152.1	62.1	138.9	94.4	80.0	77.6	72.8	149.7	31.0
290.0	87.2	154.5	52.5	142.5	81.2	82.4	75.2	75.2	153.3	31.0
295.0	90.9	157.0	52.6	146.1	74.1	83.7	77.7	80.1	157.0	31.0
300.0	94.4	159.4	53.8	149.8	74.1	83.7	78.9	83.7	159.4	31.1
305.0	98.0	161.8	53.8	153.4	74.1	84.9	81.3	83.7	163.0	31.1
310.0	100.4	164.2	54.9	157.0	75.3	87.3	78.9	77.7	165.4	31.1
315.0	102.8	166.6	57.3	159.4	76.5	90.9	80.1	80.1	169.0	31.1
320.0	105.2	169.0	58.5	163.0	75.3	112.5	89.7	74.1	172.7	31.1
325.0	107.7	171.5	58.6	166.7	75.3	114.9	99.3	72.9	175.1	31.1
330.0	111.3	173.9	62.2	169.1	74.1	130.5	118.5	72.9	176.3	32.3
335.0	114.9	176.3	65.8	171.5	74.1	135.4	140.2	76.5	179.9	32.3
340.0	117.3	177.5	66.9	176.3	75.3	142.6	147.4	78.9	182.4	32.3
345.0	118.5	179.9	68.1	177.5	75.3	145.0	153.4	83.7	184.8	32.3
350.0	120.9	179.9	69.4	179.9	75.3	146.2	155.9	83.8	186.0	32.4

LOCA 8 Temperature Data (Time in Seconds, Temperatures in °C)

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
0.0	61.4	59.0	60.2	56.7	59.0	51.9	50.7	44.7	61.4	24.4
5.0	61.4	61.4	61.4	57.8	59.0	51.9	50.7	44.7	61.4	24.4
10.0	62.6	62.6	62.6	59.0	59.0	51.9	50.7	44.7	62.6	24.4
15.0	62.6	63.8	62.6	60.2	59.0	53.1	50.7	45.9	62.6	24.4
20.0	63.8	65.0	62.6	60.2	60.2	53.1	51.9	45.9	63.8	25.7
25.0	63.8	66.2	63.8	61.4	60.3	53.1	51.9	45.9	63.8	25.6
30.0	65.0	66.3	63.9	61.4	61.5	54.3	51.9	47.1	63.8	25.7
35.0	65.0	67.5	65.0	62.6	61.4	54.3	53.1	47.1	65.0	25.7
40.0	66.2	69.8	66.2	62.6	62.6	55.5	53.1	47.1	66.2	25.6
45.0	67.4	71.0	69.8	65.0	63.8	55.5	54.3	48.3	67.4	25.6
50.0	68.6	72.2	71.0	66.2	65.0	57.8	55.5	48.3	68.6	24.4
55.0	69.8	73.4	72.2	68.6	67.4	57.8	56.7	49.5	69.8	25.6
60.0	69.9	73.4	72.2	69.8	68.6	59.0	56.7	49.5	71.0	24.4
65.0	69.9	74.6	73.4	71.1	69.9	60.3	57.9	50.7	72.2	25.6
70.0	69.9	75.8	74.6	71.1	71.1	61.5	59.0	51.9	73.4	25.7
75.0	71.1	77.0	74.6	72.2	72.2	62.7	60.3	51.9	74.6	24.5
80.0	71.1	79.4	74.6	73.4	73.4	63.9	61.5	51.9	77.0	25.7
85.0	71.1	81.8	74.6	75.8	75.8	65.1	63.9	55.5	79.4	24.5
90.0	71.1	84.2	75.8	79.4	78.2	66.3	69.9	55.5	81.8	24.5
95.0	71.1	86.6	75.8	74.6	74.6	68.7	71.1	56.7	86.6	25.7
100.0	71.1	85.4	77.0	77.0	77.0	71.1	72.2	60.3	91.4	24.5
105.0	71.1	84.2	75.8	77.0	75.8	71.1	73.4	61.5	96.2	25.7
110.0	71.1	89.0	77.0	78.2	77.0	74.6	74.6	62.7	99.8	25.7
115.0	72.2	95.0	78.2	92.6	81.8	77.0	75.8	65.1	103.4	25.7
120.0	72.2	98.6	90.2	104.6	91.4	81.8	77.0	67.5	107.0	25.7
125.0	72.2	99.8	98.6	105.8	104.6	77.0	75.8	69.9	110.6	25.7
130.0	72.2	98.7	102.2	101.1	109.4	78.3	77.0	71.1	114.2	25.7
135.0	71.1	101.0	105.8	102.2	114.2	81.8	78.2	72.2	119.0	25.7
140.0	71.1	105.8	107.0	83.0	122.6	79.4	79.4	73.4	122.6	24.5
145.0	72.2	109.4	109.4	87.8	126.2	80.6	84.2	74.6	126.2	24.5
150.0	72.2	113.0	111.8	93.8	129.8	83.0	86.6	77.0	129.8	24.5
155.0	72.2	115.4	114.2	98.6	133.5	89.0	87.8	80.6	133.5	24.5
160.0	72.2	119.0	116.6	101.0	138.3	92.6	87.8	83.0	137.1	24.5

LOFA 2 Temperature Data (Time in Seconds, Temperatures in °C)

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
0.0	48.6	47.4	47.4	43.8	43.8	41.4	41.4	41.4	45.0	39.0
5.0	48.6	47.4	47.4	43.8	43.8	41.4	41.4	40.2	45.0	39.0
10.0	48.6	47.4	47.4	43.8	43.8	41.4	41.4	40.3	45.0	39.1
15.0	48.6	47.4	47.4	43.8	43.8	41.4	41.4	41.4	45.0	39.1
20.0	48.6	47.4	47.4	43.8	43.8	41.4	41.4	40.3	45.0	39.1
25.0	48.7	47.5	47.4	43.8	43.9	41.4	41.4	40.3	45.1	39.1
30.0	48.7	47.5	47.5	43.9	43.9	41.5	41.5	40.3	45.1	39.1
35.0	48.7	47.5	47.5	43.9	43.9	41.5	41.5	40.3	45.1	39.1
40.0	48.7	48.7	47.5	45.1	45.1	42.7	42.7	41.5	45.1	39.1
45.0	48.7	49.9	49.9	46.3	45.1	43.9	43.9	41.5	46.3	39.1
50.0	48.7	51.1	51.1	46.3	46.3	45.1	45.1	42.7	47.5	39.2
55.0	49.9	53.5	52.3	47.5	47.5	45.1	46.3	42.7	48.7	39.2
60.0	51.1	54.7	54.7	48.7	47.5	46.3	46.3	44.0	51.1	39.2
65.0	51.1	57.1	55.9	49.9	47.6	47.6	47.6	45.2	52.3	39.2
70.0	53.5	58.3	58.3	49.9	47.6	47.6	46.4	45.2	54.7	39.2
75.0	53.5	60.7	59.5	51.1	48.8	47.6	47.6	46.4	55.9	39.2
80.0	54.7	61.9	60.7	52.3	48.8	48.8	47.6	47.6	58.3	39.2
85.0	55.9	63.1	61.9	53.5	49.9	48.8	48.8	47.6	59.5	39.2
90.0	57.2	64.3	63.1	53.6	51.2	50.0	48.8	47.6	60.7	39.3
95.0	58.4	64.3	64.3	53.6	51.2	50.0	48.8	48.8	61.9	40.4
100.0	59.6	65.5	65.5	54.8	52.4	51.2	50.0	48.8	61.9	40.4
105.0	60.8	65.6	65.6	54.8	52.4	51.2	50.0	48.8	63.2	40.5
110.0	62.0	66.8	66.8	54.8	53.6	51.2	50.0	50.0	64.4	40.5
115.0	63.2	66.8	66.8	56.0	53.6	52.4	50.0	50.0	65.6	40.5
120.0	64.4	66.8	66.8	56.1	53.7	52.5	50.1	50.1	65.6	40.5
125.0	64.4	66.8	66.8	56.1	53.7	52.5	51.3	51.3	65.6	40.5
130.0	65.7	66.9	66.8	56.1	53.7	52.5	51.3	51.3	66.9	40.5
135.0	65.7	65.7	66.9	56.1	53.7	52.5	51.3	51.3	66.9	40.6
140.0	66.9	64.5	66.9	57.3	53.7	52.5	51.3	51.3	66.9	41.8
145.0	66.9	63.3	66.9	57.3	54.9	53.7	51.3	51.3	68.1	40.6
150.0	68.1	62.1	65.7	57.4	55.0	53.8	51.4	51.4	68.1	41.8
155.0	68.1	60.9	64.5	57.4	55.0	53.8	51.4	51.4	68.1	41.8
160.0	68.1	59.7	63.3	57.4	55.0	53.8	52.6	52.6	69.3	41.8
165.0	68.1	59.7	62.1	57.4	55.0	53.8	52.6	52.6	69.4	41.8
170.0	69.4	58.6	61.0	57.4	55.0	53.8	52.6	52.6	69.4	41.9
175.0	69.4	58.6	59.8	57.4	55.0	53.8	52.6	52.6	69.4	41.9
180.0	69.4	58.6	58.6	57.4	56.2	53.8	52.6	52.6	69.4	41.9
185.0	69.4	57.5	58.6	58.6	55.1	53.9	52.7	52.7	70.6	41.9

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
190.0	68.2	57.5	58.6	58.6	55.1	55.1	52.7	53.9	70.6	41.9
195.0	68.2	57.5	57.5	58.6	56.3	55.1	52.7	53.9	70.6	43.1
200.0	68.2	57.5	57.5	58.6	56.3	55.1	53.9	53.9	70.6	43.1
205.0	67.1	57.5	57.5	58.7	56.3	55.1	53.9	53.9	70.7	43.2
210.0	67.1	57.5	57.5	58.7	56.3	55.1	53.9	53.9	70.7	43.2
215.0	65.9	57.5	57.5	58.7	56.3	55.1	53.9	53.9	70.7	43.2
220.0	64.7	57.6	57.6	58.7	56.4	55.1	53.9	54.0	70.7	43.2
225.0	63.5	57.6	57.6	58.7	56.4	55.2	54.0	54.0	70.7	43.2
230.0	62.3	57.6	57.6	58.7	56.4	55.2	54.0	54.0	70.7	43.2
235.0	59.9	57.6	57.6	58.7	56.4	55.2	54.0	54.0	70.7	43.2
240.0	58.8	57.6	57.6	58.8	56.4	56.4	54.0	54.0	72.0	44.5
245.0	57.6	57.6	57.6	58.8	56.4	55.2	54.0	55.2	72.0	44.5
250.0	56.4	57.6	57.6	58.8	56.4	56.4	54.0	55.2	72.0	44.5
255.0	54.1	56.4	57.6	58.8	56.5	56.5	54.1	55.2	72.0	44.5
260.0	51.7	57.6	56.5	58.8	56.5	55.3	54.1	55.3	72.0	44.5
265.0	51.7	56.5	57.6	58.8	56.5	56.5	54.1	55.3	72.0	44.5
270.0	50.5	57.6	57.6	58.8	56.5	56.5	54.1	55.3	72.0	44.5
275.0	50.5	56.5	57.7	58.9	56.5	56.5	54.1	55.3	72.0	44.6
280.0	49.3	57.7	57.7	58.9	56.5	56.5	54.1	55.3	72.0	44.6
285.0	50.5	56.5	57.7	58.9	56.5	56.5	54.1	55.3	72.0	44.6
290.0	49.4	56.6	56.5	58.9	56.6	56.6	54.2	55.4	72.1	44.6
295.0	49.4	56.6	56.6	58.9	56.6	56.6	54.2	55.4	72.1	44.6
300.0	49.4	56.6	56.6	58.9	56.6	56.6	54.2	55.4	72.1	44.6
305.0	49.4	57.7	56.6	58.9	56.6	56.6	54.2	55.4	72.1	44.7
310.0	49.4	56.6	56.6	59.0	56.6	56.6	54.2	55.4	72.1	45.8
315.0	49.4	56.6	56.6	59.0	56.6	56.6	54.2	55.4	72.1	45.8
320.0	49.5	56.6	56.6	59.0	56.6	56.6	54.3	55.5	72.2	45.9
325.0	49.5	56.6	56.6	59.0	56.6	56.6	54.3	55.5	72.2	45.9
330.0	49.5	56.6	56.6	59.0	56.6	56.6	54.3	55.5	72.2	45.9
335.0	49.5	56.6	56.7	59.0	56.6	56.6	55.5	56.6	72.2	45.9
340.0	49.5	56.7	56.7	59.1	56.7	56.7	54.3	55.5	72.2	45.9
345.0	49.5	56.7	56.7	59.1	56.7	56.7	55.5	56.7	72.2	45.9
350.0	49.5	56.7	56.7	59.1	56.7	56.7	54.3	56.7	72.2	45.9
355.0	49.6	56.7	56.7	59.1	56.7	56.7	55.5	56.7	72.3	46.0
360.0	49.6	56.7	56.7	59.1	56.7	56.7	55.5	56.7	72.3	46.0
365.0	49.6	56.7	56.7	59.1	56.7	56.7	55.5	56.7	72.3	46.0
370.0	49.6	56.7	56.7	59.2	56.8	56.8	55.6	56.8	72.3	46.0
375.0	49.6	56.8	56.8	59.2	56.8	56.8	55.6	55.6	72.3	46.0
380.0	49.6	56.8	56.8	59.2	56.8	56.8	55.6	56.8	72.3	46.0
385.0	49.6	56.8	56.8	59.2	56.8	56.8	55.6	56.8	72.3	46.0
390.0	49.7	56.8	56.8	59.2	56.8	56.8	55.6	56.8	72.4	46.1

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
395.0	49.7	56.8	56.8	59.2	56.8	56.8	55.6	56.8	72.4	46.1
400.0	49.7	56.8	56.8	59.2	56.8	56.8	55.6	56.8	72.4	46.1
405.0	49.7	56.8	56.9	59.3	56.9	56.9	55.7	56.9	72.4	47.3
410.0	49.7	56.9	56.9	59.3	56.9	56.9	55.7	56.9	73.6	46.1
415.0	49.7	56.9	56.9	59.3	56.9	56.9	55.7	56.9	72.4	47.3
420.0	51.0	56.9	56.9	59.3	56.9	56.9	55.7	56.9	72.5	47.3
425.0	49.8	56.9	56.9	59.3	56.9	56.9	55.7	56.9	72.5	47.4
430.0	51.0	56.9	56.9	59.3	56.9	56.9	55.7	56.9	72.5	47.4
435.0	49.8	56.9	56.9	59.3	56.9	56.9	55.7	56.9	72.5	47.4
440.0	51.0	57.0	57.0	59.4	57.0	57.0	55.7	57.0	72.5	47.4
445.0	51.0	57.0	57.0	59.4	57.0	57.0	55.8	57.0	72.5	47.4
450.0	51.0	58.2	57.0	59.4	57.0	57.0	55.8	57.0	72.5	47.4
455.0	51.0	58.2	57.0	59.4	57.0	57.0	55.8	57.0	72.5	47.4
460.0	51.1	58.2	57.0	59.4	57.0	57.0	55.8	57.0	72.6	47.5
465.0	51.1	58.2	57.0	59.4	57.0	57.0	55.8	57.0	73.8	47.5
470.0	51.1	58.2	58.2	59.4	57.0	57.0	57.0	57.0	73.8	47.5
475.0	51.1	58.3	57.1	59.4	57.1	57.1	57.0	57.1	73.8	47.5
480.0	51.1	58.3	58.3	59.5	57.1	57.1	57.1	57.1	73.8	47.5
485.0	51.1	58.3	58.3	59.5	57.1	57.1	57.1	57.1	73.8	47.5
490.0	51.1	58.3	57.1	59.5	57.1	57.1	57.1	57.1	73.8	47.5
495.0	52.4	58.3	58.3	59.5	57.1	57.1	55.9	57.1	73.9	47.6
500.0	52.4	59.5	58.3	59.5	57.1	57.1	57.1	57.1	73.9	47.6
505.0	52.4	59.5	58.3	59.5	58.3	57.1	55.9	57.1	73.9	47.6
510.0	52.4	59.6	58.4	59.6	58.4	58.4	56.0	57.2	73.9	47.6
515.0	53.6	59.6	58.4	59.6	58.4	57.2	57.2	57.2	73.9	47.6
520.0	54.8	59.6	58.4	59.6	58.4	58.4	57.2	57.2	73.9	47.6
525.0	57.2	59.6	58.4	59.6	58.4	57.2	57.2	57.2	74.0	47.7
530.0	58.4	59.6	58.4	59.6	58.4	57.2	57.2	57.2	74.0	47.7
535.0	59.6	59.6	58.4	59.6	58.4	58.4	57.2	57.2	74.0	47.7
540.0	60.8	59.6	58.4	59.6	57.2	57.2	57.2	57.2	74.0	47.7
545.0	62.1	59.6	58.5	59.7	58.4	57.2	57.3	57.3	74.0	47.7
550.0	63.3	59.7	58.5	59.7	58.5	57.3	57.3	57.3	74.0	47.7
555.0	64.5	59.7	58.5	59.7	58.5	58.5	57.3	57.3	74.0	47.7
560.0	65.6	59.7	58.5	59.7	58.5	58.5	57.3	57.3	74.1	47.8
565.0	66.9	59.7	59.7	59.7	58.5	58.5	57.3	57.3	74.1	47.8
570.0	68.1	60.9	60.9	59.7	58.5	58.5	57.3	57.3	74.1	47.8
575.0	68.1	60.9	62.1	59.7	57.3	57.3	57.3	57.3	75.3	47.8
580.0	69.3	63.4	65.7	59.8	58.6	58.6	57.4	57.4	75.3	47.8
585.0	70.5	66.9	66.9	59.8	58.6	58.6	57.4	57.4	74.1	47.8
590.0	70.5	69.3	68.1	59.8	58.6	58.6	57.4	57.4	75.3	47.8
595.0	70.5	70.5	69.4	59.8	58.6	58.6	57.4	57.4	75.4	47.8

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
600.0	71.8	71.8	70.6	59.8	58.6	58.6	57.4	57.4	75.4	49.1
605.0	70.6	71.8	70.6	59.8	58.6	58.6	57.4	57.4	76.6	47.9
610.0	71.8	73.0	71.8	59.8	58.6	58.6	57.5	57.4	76.6	47.9
615.0	71.8	73.0	71.8	59.9	58.7	58.7	57.5	57.5	76.6	47.9
620.0	71.8	74.2	73.0	59.9	58.7	58.7	57.5	57.5	77.8	47.9
625.0	71.8	76.6	73.0	59.9	58.7	58.7	57.5	57.5	77.8	47.9
630.0	71.9	77.8	74.3	59.9	58.7	58.7	57.5	57.5	77.9	48.0
635.0	71.9	76.7	74.3	59.9	58.7	58.7	57.5	57.5	76.7	48.0
640.0	71.9	76.7	74.3	59.9	58.7	58.7	57.5	57.5	76.7	48.0
645.0	71.9	76.7	75.5	59.9	58.7	58.7	57.5	57.5	77.9	48.0
650.0	71.9	76.7	74.3	60.0	58.8	58.8	57.6	57.6	77.9	48.0
655.0	71.9	75.5	74.3	60.0	58.8	58.8	57.6	57.6	77.9	48.0
660.0	71.9	75.5	74.3	60.0	58.8	58.8	57.6	57.6	77.9	48.0
665.0	71.9	75.5	74.4	60.0	58.8	58.8	57.6	57.6	79.2	48.1
670.0	72.0	75.6	73.2	60.0	58.8	58.8	57.6	57.6	79.2	48.1
675.0	72.0	75.6	73.2	61.2	60.0	58.8	57.6	57.6	79.2	48.1
680.0	72.0	74.4	73.2	63.6	61.2	58.8	57.6	57.6	80.3	48.1
685.0	72.0	74.4	73.2	68.4	63.6	58.9	57.7	57.7	81.6	48.1
690.0	72.0	75.6	73.2	69.6	68.4	58.9	56.5	57.7	81.6	48.1
695.0	72.0	75.6	73.2	72.0	70.8	58.9	56.5	57.7	81.6	49.3
700.0	72.1	75.7	73.3	72.0	70.9	57.7	56.5	57.7	82.8	48.1
705.0	72.1	75.7	73.3	73.3	72.1	57.7	55.3	57.7	82.8	48.2
710.0	72.1	75.7	73.3	74.5	72.1	57.7	55.3	57.7	84.0	48.2
715.0	72.1	75.7	73.3	76.9	72.1	57.7	55.3	57.7	85.2	48.2
720.0	72.1	76.9	73.3	79.2	73.3	57.8	55.4	57.8	86.5	48.2
725.0	72.1	76.9	73.3	79.3	75.7	57.8	55.4	57.8	88.9	48.2
730.0	72.1	76.9	73.3	75.7	79.3	57.8	55.4	57.8	91.3	49.4
735.0	72.1	78.1	73.4	74.6	76.9	60.2	56.6	57.8	92.5	49.4
740.0	72.2	78.1	73.4	74.6	75.8	67.4	57.8	57.8	94.9	50.6
745.0	72.2	78.1	73.4	74.6	74.6	68.6	61.4	57.8	97.3	50.6
750.0	63.8	78.1	73.4	74.6	74.6	69.8	69.8	57.8	99.7	50.6
755.0	56.7	78.1	73.4	73.4	74.6	71.0	71.0	57.9	101.0	50.7
760.0	68.6	78.2	74.6	73.4	74.6	71.0	72.2	57.9	103.4	51.9
765.0	71.0	79.4	74.6	73.4	74.6	72.2	72.2	59.1	105.8	51.9
770.0	71.0	79.4	74.6	73.4	75.8	72.2	73.4	59.1	108.2	51.9
775.0	71.1	79.4	74.7	73.5	74.7	74.7	75.9	59.1	110.6	51.9
780.0	71.1	79.4	74.7	73.5	75.9	74.7	79.4	63.9	111.8	51.9
785.0	72.3	80.6	75.9	74.7	75.9	74.7	80.6	67.5	114.2	51.9
790.0	71.1	81.9	75.9	74.7	75.9	73.5	77.1	68.7	116.7	53.2
795.0	72.3	81.9	75.9	74.7	75.9	73.5	75.9	71.1	117.9	52.0
800.0	72.3	81.9	75.9	74.7	75.9	72.3	75.9	71.1	120.3	52.0

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
805.0	72.4	83.1	77.1	74.8	75.9	72.4	75.9	71.2	121.5	52.0
810.0	72.4	83.1	77.1	75.9	75.9	72.4	75.9	72.4	123.9	52.0
815.0	72.4	84.3	77.1	75.9	75.9	72.4	75.9	72.4	125.1	50.8
820.0	72.4	85.6	78.4	77.2	76.0	72.4	77.2	73.6	127.6	50.8
825.0	72.4	86.8	82.0	78.4	77.2	72.4	77.2	76.0	128.8	52.1
830.0	71.2	88.0	84.4	80.8	78.4	73.6	82.0	77.2	131.2	52.1
835.0	71.2	91.6	89.2	90.4	82.0	73.6	91.6	78.4	132.4	52.1
840.0	71.3	97.6	98.8	98.8	88.0	74.8	104.8	78.4	133.7	53.3
845.0	72.5	106.0	100.0	109.6	103.6	76.0	101.2	73.7	136.1	53.3
850.0	72.5	113.2	101.2	109.6	116.8	77.2	102.4	73.7	137.3	53.3
855.0	71.3	118.1	103.6	113.3	116.8	78.4	109.6	76.1	138.5	54.5
860.0	71.3	124.1	106.1	120.5	121.7	79.7	114.5	78.5	139.7	55.8
865.0	72.5	126.5	108.5	115.7	121.7	77.3	115.7	83.3	142.1	55.8
870.0	71.3	131.3	108.5	118.1	122.9	85.7	104.9	88.1	143.3	55.8
875.0	71.4	131.4	107.3	118.1	114.5	88.1	113.3	86.9	144.6	55.8
880.0	71.4	130.2	107.3	122.9	119.3	96.5	118.1	83.3	147.0	55.8
885.0	71.4	129.0	110.9	121.7	121.7	96.5	122.9	80.9	148.2	55.8
890.0	71.4	127.7	109.7	127.7	121.7	90.5	124.1	80.9	149.4	55.8
895.0	72.6	135.0	114.6	130.2	119.4	93.0	127.8	84.6	151.9	55.9
900.0	71.4	135.0	125.4	129.0	120.6	94.2	129.0	94.2	151.9	57.1
905.0	71.4	133.8	132.6	129.0	123.0	107.4	133.8	91.8	154.3	57.1

LOFA 4 Temperature Data (Time in Seconds, Temperatures in °C)

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
0.0	55.5	50.7	51.9	50.7	50.7	49.5	50.7	48.3	53.1	45.9
5.0	55.5	50.7	51.9	50.7	50.7	49.5	50.7	48.3	53.1	45.9
10.0	55.5	50.7	51.9	50.7	50.7	49.5	50.7	48.3	53.1	45.9
15.0	55.5	50.7	51.9	50.7	50.7	49.5	50.7	48.4	53.1	46.0
20.0	55.5	50.7	51.9	50.7	50.7	49.5	50.7	48.4	53.1	46.0
25.0	55.5	50.7	50.7	50.7	50.7	49.5	50.7	48.4	53.1	46.0
30.0	55.5	50.7	50.7	50.7	50.7	49.5	50.7	48.4	53.1	46.0
35.0	55.6	50.7	51.9	50.7	50.7	49.5	50.8	48.4	53.1	46.0
40.0	55.6	50.8	52.0	52.0	52.0	50.8	52.0	49.6	54.4	46.0
45.0	56.8	52.0	53.2	53.2	53.2	52.0	53.2	49.6	56.8	46.0
50.0	58.0	53.2	54.4	54.4	55.6	52.0	54.4	49.6	58.0	46.0
55.0	58.0	54.4	55.6	55.6	56.8	53.2	55.6	50.8	60.4	46.1
60.0	54.4	54.4	56.8	56.8	56.8	53.2	55.6	50.8	62.8	46.1
65.0	52.0	55.6	58.0	58.0	58.0	54.4	56.8	52.0	64.0	46.1
70.0	52.0	55.6	58.0	58.0	59.2	55.6	56.8	52.0	65.2	46.1
75.0	52.1	55.7	59.2	59.2	60.4	55.7	58.0	53.3	67.6	46.1
80.0	52.1	56.9	59.2	60.4	60.4	55.7	58.1	53.3	68.8	46.1
85.0	52.1	56.9	59.2	60.4	61.6	56.9	59.2	54.5	70.0	46.1
90.0	52.1	56.9	60.4	60.4	61.6	56.9	59.2	54.5	71.2	46.1
95.0	53.3	56.9	60.4	61.7	61.7	56.9	59.3	54.5	72.5	46.1
100.0	53.3	56.9	60.5	61.7	62.9	56.9	60.5	54.5	72.5	46.2
105.0	53.3	56.9	60.5	61.7	62.9	58.1	60.5	55.7	73.7	46.2
110.0	53.3	58.1	60.5	62.9	64.1	58.1	60.5	55.7	74.8	46.2
115.0	53.3	57.0	60.5	62.9	64.1	58.1	60.5	55.7	76.0	46.2
120.0	53.4	58.2	60.5	62.9	64.1	58.2	60.5	55.8	76.1	46.2
125.0	53.4	57.0	60.6	63.0	64.2	58.2	60.6	55.8	77.3	46.2
130.0	54.6	58.2	60.6	63.0	64.2	58.2	61.8	55.8	77.3	46.3
135.0	54.6	58.2	60.6	63.0	64.2	58.2	60.6	55.8	77.3	46.3
140.0	54.6	58.2	60.6	64.2	64.2	58.2	60.6	55.8	78.5	46.3
145.0	54.6	58.2	60.6	64.2	64.2	58.2	60.6	55.8	78.5	46.3
150.0	54.6	58.2	60.6	64.2	64.2	58.2	61.8	57.0	78.5	47.4
155.0	54.6	58.2	60.6	64.2	64.2	58.2	61.8	57.0	78.5	47.4
160.0	55.9	58.2	61.8	64.2	64.2	58.2	61.8	57.1	79.8	46.3
165.0	55.9	58.2	60.6	64.2	64.2	58.2	61.9	57.1	79.8	47.5
170.0	54.7	58.3	60.7	64.3	64.3	58.3	61.9	57.1	79.8	47.5
175.0	54.7	58.3	60.7	64.3	64.3	58.3	61.9	57.1	81.0	47.5
180.0	55.9	58.3	60.7	64.3	64.3	59.5	61.9	57.1	79.8	47.5
185.0	55.9	58.3	60.7	64.3	64.3	58.3	61.9	57.1	79.8	46.4

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
190.0	56.0	58.3	60.7	64.3	64.3	58.3	61.9	57.2	81.1	46.4
195.0	56.0	58.3	61.9	64.3	64.3	59.5	61.9	57.2	81.1	47.6
200.0	56.0	58.3	60.7	64.3	64.3	59.5	61.9	57.2	82.3	46.4
205.0	56.0	58.4	62.0	64.4	64.4	59.5	61.9	57.2	82.3	47.6
210.0	56.0	58.3	61.9	64.3	64.3	59.5	61.9	57.2	82.3	47.6
215.0	56.0	58.3	61.9	64.3	64.3	59.5	61.9	57.2	82.3	47.6
220.0	56.0	58.4	62.0	65.6	65.6	59.6	62.0	57.2	83.5	47.6
225.0	56.0	58.4	62.0	64.4	65.6	59.6	62.0	57.2	83.5	47.6
230.0	56.0	58.4	62.0	64.4	65.6	59.6	62.0	57.2	84.7	47.6
235.0	56.1	58.4	62.0	64.4	65.6	59.6	62.0	57.2	83.6	47.7
240.0	56.1	58.4	63.2	64.4	65.6	59.6	62.0	57.2	83.6	47.7
245.0	56.1	58.4	63.2	64.4	65.6	59.6	62.0	57.2	83.6	47.7
250.0	56.1	58.4	63.2	64.4	65.6	59.6	62.0	57.2	83.6	47.7
255.0	57.2	58.5	64.5	64.5	66.9	59.7	62.1	57.3	84.8	47.7
260.0	57.3	59.7	64.5	64.5	66.9	59.7	62.1	57.3	84.8	47.7
265.0	58.5	58.5	64.5	65.7	66.9	58.5	62.1	57.3	83.6	47.7
270.0	60.9	58.5	64.5	64.5	66.9	59.7	62.1	57.3	84.9	47.7
275.0	62.1	58.5	64.5	64.5	66.9	59.7	62.1	57.3	83.7	47.7
280.0	65.7	58.5	65.7	64.5	66.9	59.7	63.3	57.3	83.7	47.8
285.0	68.1	58.5	65.7	64.5	66.9	59.7	63.3	57.3	83.7	47.8
290.0	69.3	58.5	65.7	65.7	66.9	59.7	63.3	57.3	83.7	47.8
295.0	70.5	58.5	65.8	65.8	66.9	59.7	63.4	57.4	84.9	47.8
300.0	70.5	58.6	67.0	65.8	67.0	59.8	63.4	57.4	83.7	47.8
305.0	71.7	59.8	67.0	65.8	67.0	59.8	63.4	57.4	83.7	47.8
310.0	71.8	59.8	67.0	65.8	67.0	59.8	63.4	57.4	85.0	47.9
315.0	71.8	58.6	67.0	65.8	67.0	59.8	63.4	57.4	83.8	47.9
320.0	71.8	59.8	67.0	65.8	67.0	59.8	63.4	57.4	83.8	47.9
325.0	71.8	59.9	67.1	65.9	67.1	59.9	64.7	57.5	83.8	47.9
330.0	71.8	63.5	68.3	65.9	67.1	59.9	65.9	57.5	82.6	47.9
335.0	71.8	64.7	70.6	65.9	67.1	59.9	65.9	57.5	82.6	47.9
340.0	71.8	69.4	71.8	67.1	67.1	59.9	65.9	57.5	82.6	47.9
345.0	71.8	73.1	74.2	69.5	67.1	59.9	65.9	57.5	81.5	48.0
350.0	71.9	75.5	75.5	70.7	67.1	58.7	65.9	57.5	82.7	48.0
355.0	71.9	75.5	75.5	71.9	68.3	58.7	65.9	57.5	81.5	48.0
360.0	71.9	74.3	77.9	71.9	67.1	58.7	65.9	57.5	80.3	48.0
365.0	71.9	73.1	81.5	71.9	67.1	58.7	64.7	57.5	79.1	48.0
370.0	71.9	73.1	80.3	71.9	67.2	58.8	64.8	57.6	79.1	48.0
375.0	71.9	71.9	80.3	71.9	67.2	58.8	64.8	57.6	79.1	48.0
380.0	71.9	71.9	81.5	71.9	67.2	60.0	64.8	57.6	79.1	48.0
385.0	71.9	71.9	81.5	71.9	68.3	58.8	64.8	57.6	81.5	48.0
390.0	72.0	71.9	82.7	71.9	68.4	58.8	64.8	57.6	81.5	48.0

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
395.0	73.2	72.0	84.0	73.2	68.4	58.8	64.8	57.6	82.8	48.1
400.0	73.2	72.0	85.2	73.2	68.4	58.8	64.8	57.6	84.0	46.9
405.0	73.2	72.0	85.2	74.4	68.4	58.8	64.8	57.6	84.0	48.1
410.0	73.2	72.0	86.4	74.4	69.6	58.9	64.9	57.7	85.2	46.9
415.0	73.2	72.0	87.6	75.6	69.6	58.9	66.1	57.7	87.6	46.9
420.0	73.2	72.0	90.0	76.8	70.8	58.9	66.1	57.7	88.8	46.9
425.0	74.4	72.0	91.2	79.2	70.8	58.9	66.1	57.7	92.4	46.9
430.0	73.2	72.0	92.4	80.4	72.0	58.9	66.1	57.7	94.8	46.9
435.0	74.5	72.1	94.8	82.9	75.7	58.9	66.1	57.7	98.4	47.0
440.0	74.5	72.1	96.0	86.5	79.3	58.9	66.1	57.7	100.8	47.0
445.0	74.5	72.1	97.2	88.9	85.3	58.9	67.3	57.7	104.4	47.0
450.0	74.5	72.1	102.0	81.7	87.7	59.0	67.3	57.8	108.0	47.0
455.0	74.5	72.1	106.9	97.3	82.9	60.2	67.3	57.8	110.5	47.0
460.0	74.5	72.1	105.7	100.9	80.5	60.2	67.3	57.8	114.1	47.0
465.0	74.5	72.1	109.3	105.7	79.3	60.2	67.3	57.8	118.9	47.1
470.0	74.5	72.1	110.5	109.3	82.9	61.4	67.3	57.8	122.5	47.0
475.0	75.8	72.2	113.0	110.5	97.3	61.4	68.6	57.8	127.4	47.1
480.0	75.8	72.2	117.8	114.2	105.7	62.6	69.8	56.6	131.0	47.1
485.0	75.8	72.2	132.2	116.6	110.5	62.6	71.0	57.8	134.6	47.1
490.0	75.8	72.2	131.0	121.4	117.8	65.0	72.2	57.8	138.3	47.1
495.0	77.0	72.2	131.0	122.6	122.6	71.0	74.6	57.9	140.7	47.1
500.0	63.9	72.2	132.2	123.8	131.0	74.6	79.4	57.9	144.3	47.1
505.0	79.4	72.2	134.6	127.4	133.4	83.0	85.4	57.9	147.9	45.9
510.0	54.3	72.2	133.4	129.8	137.1	84.2	78.2	57.9	150.3	45.9
515.0	48.4	72.3	134.7	132.3	139.5	79.5	75.9	62.7	154.0	45.9
520.0	46.0	72.3	128.7	135.9	143.1	77.1	74.7	62.7	157.6	47.2
525.0	46.0	72.3	133.5	138.4	146.8	74.7	74.7	67.5	160.0	47.2
530.0	52.0	72.3	138.3	138.3	148.0	73.5	74.7	71.1	163.7	46.0
535.0	65.2	72.3	144.4	134.7	149.2	73.5	75.9	71.1	167.3	46.0
540.0	69.9	73.5	146.8	142.0	151.6	73.5	75.9	71.1	169.7	46.0
545.0	71.2	73.6	148.0	145.6	155.3	73.6	76.0	72.4	172.1	46.1
550.0	71.2	73.6	148.0	150.4	157.7	73.6	77.2	74.8	174.6	44.9
555.0	71.2	73.6	149.2	152.9	160.1	73.6	77.2	76.0	178.2	44.9
560.0	74.8	73.6	151.7	154.1	162.5	74.8	78.4	74.8	180.6	44.9
565.0	80.8	82.0	156.5	140.9	163.8	83.2	77.2	73.6	183.1	44.9

LOFA 6 Temperature Data (Time in Seconds, Temperatures in °C)

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
0.0	63.8	62.6	61.4	50.6	49.4	49.4	49.4	49.4	56.6	45.8
5.0	63.8	62.6	61.4	50.6	49.4	49.4	49.4	49.4	56.6	45.8
10.0	63.8	62.6	61.4	50.6	49.4	49.4	49.4	49.4	56.6	45.8
15.0	63.8	62.6	61.4	50.6	49.4	49.4	49.4	49.4	55.4	45.8
20.0	63.8	62.6	61.4	50.6	49.4	49.4	49.4	49.4	56.5	45.8
25.0	63.7	62.5	61.3	50.6	49.4	49.4	49.4	49.4	56.5	45.8
30.0	63.7	62.5	61.3	50.6	49.4	49.4	49.4	49.4	55.4	45.8
35.0	63.8	62.6	61.4	51.8	49.4	49.4	49.4	49.4	55.4	45.8
40.0	63.8	63.8	61.4	51.8	50.6	50.6	49.4	49.4	56.6	45.8
45.0	64.9	64.9	62.6	53.0	50.6	51.8	50.6	49.4	59.0	45.8
50.0	64.9	66.1	62.6	54.2	51.8	51.8	50.6	50.6	61.4	45.8
55.0	66.1	67.3	62.6	54.2	53.0	53.0	51.8	51.8	62.6	45.8
60.0	67.3	67.3	61.4	55.4	53.0	54.2	51.8	51.8	64.9	45.8
65.0	68.5	67.3	59.0	56.6	54.2	55.4	53.0	53.0	66.1	45.8
70.0	69.7	63.8	55.4	56.6	54.2	55.4	54.2	53.0	68.5	45.8
75.0	69.7	61.4	54.2	57.8	55.4	56.6	54.2	54.2	69.7	45.8
80.0	70.9	61.4	54.2	57.8	55.4	56.6	54.2	54.2	70.9	45.8
85.0	70.9	63.8	54.2	57.8	55.4	57.8	55.4	55.4	72.1	45.8
90.0	71.0	63.8	54.2	59.0	55.4	57.8	55.4	55.4	73.4	45.9
95.0	71.0	63.8	55.4	59.0	55.4	57.8	55.4	55.4	74.5	45.9
100.0	72.2	67.4	56.6	59.0	56.6	59.0	55.4	55.4	74.5	45.9
105.0	72.1	69.7	60.2	59.0	56.6	59.0	56.6	55.4	75.8	45.8
110.0	72.2	71.0	63.8	60.2	56.6	59.0	56.6	56.6	75.8	45.9
115.0	72.2	74.6	71.0	68.6	56.6	59.0	56.6	56.6	75.8	47.1
120.0	72.2	78.2	73.4	68.6	59.0	59.0	56.6	56.6	75.8	47.1
125.0	72.2	80.6	74.6	68.6	61.4	59.0	56.6	56.6	75.8	47.1
130.0	75.8	83.0	75.8	69.8	63.8	59.0	56.6	56.6	75.8	47.1
135.0	74.6	78.2	77.0	69.8	63.8	59.0	56.6	56.6	75.8	47.1
140.0	73.3	78.2	75.8	69.8	63.8	60.2	56.6	56.6	75.8	47.1
145.0	73.4	79.4	75.8	71.0	65.0	59.0	56.6	56.6	77.0	47.1
150.0	73.4	80.6	73.4	71.0	65.0	59.0	56.6	56.6	77.0	47.1
155.0	73.4	83.0	73.4	72.2	65.0	59.0	56.6	56.6	78.2	47.1
160.0	73.4	84.1	72.2	73.4	66.2	59.0	56.6	56.6	79.4	47.1
165.0	73.4	85.3	72.2	74.6	66.2	59.0	56.7	56.7	80.6	47.1
170.0	73.4	87.8	72.2	74.6	67.4	59.1	56.7	57.9	81.8	47.1
175.0	73.4	89.0	73.4	75.8	69.8	59.1	56.7	56.7	84.2	47.1
180.0	73.4	92.6	72.2	78.2	74.6	59.1	56.7	56.7	86.6	47.1
185.0	73.4	96.2	73.4	84.2	75.8	59.1	57.9	56.7	90.2	47.1

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
190.0	74.6	99.8	73.4	89.0	78.2	59.1	57.9	57.9	93.8	47.1
195.0	73.4	103.4	73.4	93.8	79.4	59.1	57.9	56.7	98.6	45.9
200.0	74.6	107.0	73.4	99.8	77.0	65.0	63.8	56.7	104.6	45.9
205.0	74.6	110.6	73.4	105.8	77.0	72.2	71.0	56.7	109.4	45.9
210.0	74.6	113.0	74.6	110.6	77.0	74.6	72.2	57.9	114.2	45.9
215.0	75.8	116.6	74.6	115.4	78.2	77.0	72.2	59.1	119.0	45.9
220.0	85.3	120.2	75.8	120.2	77.0	81.8	73.4	62.6	125.0	45.9
225.0	87.8	122.6	78.2	125.0	77.0	86.6	74.6	67.4	129.8	45.9
230.0	92.5	125.0	80.6	128.6	78.2	80.6	73.4	71.0	135.8	45.9
235.0	88.9	128.6	84.2	129.8	77.0	98.5	73.4	73.4	140.6	45.9
240.0	83.0	131.0	86.6	126.2	79.4	105.8	73.4	75.8	145.5	45.9
245.0	78.2	134.6	93.8	139.5	103.4	116.6	73.4	79.4	149.1	45.9
250.0	98.6	138.2	103.4	146.7	102.2	122.6	73.4	83.0	153.9	45.9
255.0	97.4	134.6	114.2	140.7	127.4	98.6	77.0	85.4	155.1	45.9
260.0	91.4	135.8	127.4	150.3	145.5	97.4	80.6	81.8	157.5	45.9
265.0	81.8	138.2	137.0	149.1	127.4	113.0	83.0	80.6	161.1	45.9
270.0	78.2	139.5	139.5	151.5	122.6	122.6	86.6	89.0	164.8	47.1
275.0	77.1	143.1	137.1	157.6	143.1	125.1	101.0	89.0	168.4	49.6
280.0	75.9	145.5	138.3	161.2	154.0	129.9	86.6	86.6	170.8	50.8
285.0	77.1	149.1	143.1	166.0	158.8	134.6	91.4	89.0	175.6	51.9
290.0	77.1	151.5	145.5	169.6	163.6	140.7	109.4	91.4	178.1	53.1

LOFA 8 Temperature Data (Time in Seconds, Temperatures in °C)

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
0.0	63.7	66.0	64.9	58.9	60.1	49.3	46.9	48.1	61.3	42.2
5.0	63.7	66.0	64.9	58.9	60.1	49.3	46.9	48.1	61.3	42.2
10.0	64.9	66.1	64.9	58.9	60.1	49.3	46.9	48.2	61.3	42.2
15.0	63.7	66.0	66.0	60.1	60.1	49.3	46.9	48.1	61.3	42.2
20.0	64.9	66.0	66.1	60.1	60.1	50.6	46.9	48.1	61.3	42.2
25.0	64.9	66.0	66.0	60.1	60.1	49.3	46.9	48.2	61.3	42.2
30.0	64.9	66.0	66.0	60.1	60.1	49.3	47.0	48.1	61.3	42.2
35.0	64.9	66.1	66.1	60.1	60.1	50.6	47.0	48.2	62.5	42.2
40.0	64.9	67.3	67.3	60.1	62.5	50.6	48.2	49.4	63.7	42.2
45.0	66.1	68.5	69.7	62.5	63.7	51.8	48.2	50.6	64.9	42.2
50.0	67.3	70.9	70.9	63.7	66.1	54.1	49.4	51.8	67.3	42.2
55.0	68.5	70.9	70.9	66.1	68.5	55.3	50.6	51.8	70.9	42.2
60.0	69.7	70.9	70.9	67.3	69.7	56.5	50.6	52.9	73.3	43.4
65.0	69.7	70.9	70.9	66.1	69.7	57.7	51.8	54.1	74.5	43.4
70.0	70.9	72.1	73.3	66.1	69.7	58.9	51.8	55.3	74.5	43.4
75.0	70.9	72.1	75.7	69.7	68.5	58.9	52.9	56.5	75.7	43.4
80.0	70.9	73.3	74.5	70.9	70.9	60.1	52.9	57.7	78.1	44.6
85.0	70.9	73.3	73.3	70.9	70.9	61.3	52.9	57.7	79.3	44.6
90.0	70.9	72.1	73.3	69.7	70.9	61.3	54.1	59.0	81.7	44.6
95.0	70.9	72.1	74.5	69.7	70.9	61.4	54.2	59.0	82.9	44.6
100.0	72.1	72.1	74.5	68.5	70.9	62.6	54.2	60.2	84.1	44.6
105.0	70.9	72.1	74.5	68.5	69.7	62.6	54.2	60.2	85.3	44.6
110.0	70.9	72.1	74.5	67.3	70.9	62.6	54.2	60.2	85.3	44.6
115.0	72.1	72.1	74.5	68.5	69.7	62.6	55.4	61.4	85.3	45.8
120.0	70.9	72.1	74.5	68.5	69.7	62.6	55.4	61.4	86.5	45.8
125.0	72.1	72.1	75.7	68.5	68.5	63.8	55.4	61.4	85.3	45.8
130.0	74.5	72.1	78.1	69.7	68.5	63.8	56.6	61.4	84.1	45.8
135.0	76.9	72.1	75.7	69.7	70.9	63.8	56.6	61.4	84.1	45.8
140.0	77.0	74.6	78.1	70.9	73.4	63.8	56.6	61.4	85.3	45.8
145.0	75.8	74.5	79.4	73.4	77.0	63.8	56.6	61.4	87.7	45.9
150.0	77.0	73.4	78.2	74.6	79.3	63.8	59.0	61.4	90.1	45.9
155.0	78.2	73.4	79.4	74.6	83.0	63.8	57.8	61.4	93.7	45.9
160.0	79.4	72.2	80.6	69.8	79.4	63.8	56.6	61.4	97.3	45.9
165.0	80.6	72.2	80.6	68.6	74.6	63.8	56.6	62.6	99.7	45.9
170.0	83.0	72.2	80.6	68.6	73.4	63.8	56.6	62.6	100.9	45.9
175.0	86.5	73.4	80.6	67.4	73.4	63.8	56.6	62.6	102.1	45.9
180.0	90.1	73.4	80.6	67.4	72.2	63.8	56.6	62.6	104.5	45.9
185.0	94.9	73.4	84.2	67.4	71.0	65.0	56.6	62.6	105.7	47.1

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
190.0	103.3	73.4	83.0	68.6	71.0	65.0	67.4	62.6	108.1	47.1
195.0	109.3	73.4	86.5	73.4	71.0	65.0	68.6	62.6	109.3	47.1
200.0	112.9	74.6	85.3	72.2	71.0	65.0	69.8	62.6	110.5	47.1
205.0	115.3	74.6	83.0	69.8	69.8	65.0	71.0	63.9	111.7	47.1
210.0	115.3	75.8	84.2	77.0	68.6	65.0	71.0	62.7	113.0	47.1
215.0	115.4	74.6	86.5	68.6	67.4	65.0	71.0	63.9	113.0	47.1
220.0	119.0	77.0	87.8	65.0	66.2	65.0	72.2	63.9	114.2	47.1
225.0	119.0	77.0	89.0	59.1	66.2	65.0	72.2	63.9	113.0	47.1
230.0	120.2	78.2	89.0	56.7	63.9	65.0	73.4	63.9	114.2	47.1
235.0	120.2	77.0	89.0	55.5	63.9	65.0	74.6	63.9	114.2	47.1
240.0	122.6	80.6	89.0	55.5	71.0	65.0	74.6	63.9	115.4	47.1
245.0	122.6	80.6	90.2	55.5	67.4	66.2	75.8	66.2	116.6	47.1
250.0	122.6	84.2	90.2	56.7	67.4	66.2	78.2	65.0	119.0	47.1
255.0	123.8	85.4	89.0	55.5	66.2	66.2	79.4	65.0	120.2	47.1
260.0	123.8	87.8	89.0	55.5	66.2	66.2	79.4	65.0	120.2	47.1
265.0	125.0	87.8	89.0	55.5	66.2	66.2	79.4	65.0	121.4	47.1
270.0	126.2	91.4	86.6	55.5	67.5	66.3	79.5	65.1	122.7	47.1
275.0	126.3	95.0	87.8	55.5	67.5	66.3	80.7	66.3	123.9	47.2
280.0	127.5	96.2	89.0	56.7	67.5	67.5	79.5	65.1	123.9	48.4
285.0	127.5	99.8	87.8	56.7	69.9	67.5	79.5	65.1	125.1	48.4
290.0	129.9	101.0	87.8	56.7	71.1	67.5	79.5	65.1	126.3	48.4
295.0	131.1	104.6	90.2	56.7	72.3	67.5	79.5	65.1	127.5	48.4
300.0	131.1	104.6	91.4	57.9	73.5	68.7	79.5	66.3	128.7	48.4
305.0	133.5	107.0	89.0	57.9	74.7	68.7	79.5	66.3	129.9	48.4
310.0	133.5	107.0	89.0	59.1	74.7	68.7	80.7	65.1	131.1	48.4
315.0	134.7	108.2	89.0	59.1	75.9	68.7	79.5	65.1	132.3	48.4
320.0	137.1	108.3	91.5	60.3	77.1	68.7	80.7	66.3	133.5	48.4
325.0	138.3	107.0	90.2	62.7	78.3	68.7	80.7	66.3	134.7	48.4
330.0	138.3	109.4	91.4	63.9	78.3	68.7	80.7	66.3	135.9	48.4
335.0	139.6	109.5	95.0	65.1	78.3	69.9	81.9	66.3	137.1	48.4
340.0	140.8	113.1	93.9	66.3	78.3	69.9	83.1	66.3	138.3	48.4
345.0	142.0	114.3	99.9	67.5	79.5	69.9	87.9	66.3	140.8	48.4
350.0	143.2	115.5	98.7	68.7	78.3	71.1	91.5	66.3	143.2	48.4
355.0	145.6	116.7	98.7	69.9	79.5	71.1	90.3	66.3	145.6	48.4
360.0	146.8	116.7	108.3	69.9	78.3	71.1	95.1	67.5	148.0	48.4
365.0	148.0	116.7	111.9	69.9	79.5	72.3	95.1	68.7	150.4	48.4
370.0	150.4	115.5	122.7	71.1	78.3	69.9	99.9	69.9	152.8	48.4
375.0	151.6	114.3	126.3	71.2	78.3	68.8	101.1	69.9	154.0	48.4
380.0	152.8	114.3	131.1	71.2	76.0	66.4	105.9	71.2	156.5	48.4
385.0	155.2	114.3	132.4	71.2	77.2	70.0	108.3	72.4	158.9	48.5
390.0	156.5	114.3	132.4	72.4	79.6	67.6	113.1	73.6	161.3	48.5

TIME	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
395.0	156.5	115.5	136.0	72.4	77.2	68.8	114.3	74.8	163.7	48.5
400.0	158.9	116.7	138.4	72.4	78.4	72.4	115.5	74.8	164.9	48.5
405.0	158.9	120.4	142.0	72.4	76.0	73.6	119.2	76.0	167.3	48.5
410.0	158.9	122.8	143.2	72.4	82.0	74.8	119.2	77.2	168.5	48.5
415.0	161.3	122.8	144.4	71.2	80.8	78.4	111.9	78.4	170.9	48.5

FUEL MELTING AND RELOCATION IN THE ADVANCED TEST REACTOR:
SIMULANT EXPERIMENTS IN AN OPEN GEOMETRY

Jeffrey Scott Gundersen

Under the supervision of Professor Michael L. Corradini

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