UNITED STATES AIR FORCE
GROUND ACCIDENT INVESTIGATION
BOARD REPORT

MCKINLEY CLIMATIC LABORATORY FIRE
LOCATION: EGLIN AIR FORCE BASE, FLORIDA
DATE OF ACCIDENT: 5 JULY 2017

BOARD PRESIDENT: COLONEL TRAVIS C. HARSHA

CONDUCTED IAW AIR FORCE INSTRUCTION 51-503
On 5 July 2017, at about 9:55 a.m. local, a fire occurred in Air Makeup Unit 1 (AMU1) on the
south end of the Arnold Engineering Development Complex McKinley Climatic Laboratory
(MCL) on Eglin Air Force Base (EAFB), Florida. When the fire started, a sub-contracted welder
from Universal Fabricators, Inc. (Universal) was on the east side of AMU1 using an oxy-acetylene
torch to remove a corroded structural I-beam, which was within two and a half inches of coils
containing R-30 refrigerant. Although stable at room temperature and pressures, R-30 can rupture
or explode if exposed to heat. In addition, AMU1 contained flammable insulation adhesives,
sealants, and coatings within 5 to 10 feet of the welding operations.

The fire caused extensive damage to AMU1 and adjacent Air Handling Unit (AHU), with an
estimated government loss of approximately $30 million. There were approximately 4,000 gallons
of R-30 refrigerant in AMU1, most of which was consumed by the fire. Although at least 51 first
responders or individuals on EAFB were exposed to smoke, only one individual required overnight
observation and was discharged the next day without limitations.

The MCL is the world’s largest environmental testing chamber and conducts testing for
government and private industry by simulating weather environments in its testing chambers.
AMU1 is one of MCL’s two AMUs used to create temperature changes. AMU1 uses steam boilers,
coils filled with calcium chloride (basically salt water, used as a dehumidifier), and coils filled
with methylene chloride (commonly known as R-30, used as a refrigerant) to create desired air
temperatures for testing.

Reliance Test & Technology (RT&T) performs operations and maintenance for MCL as a prime
contractor with the United States Air Force. RT&T had subcontracted with Universal to repair
portions of the AMU1 structure severely corroded by calcium chloride (salt water).
SUMMARY OF FACTS
MCKINLEY CLIMATIC LABORATORY FIRE
5 JULY 2017

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS ...................................................................................... iii
SUMMARY OF FACTS ................................................................................................................ 1
1. AUTHORITY and PURPOSE .............................................................................................. 1
   a. Authority ......................................................................................................................... 1
   b. Purpose ............................................................................................................................ 1
2. ACCIDENT SUMMARY ..................................................................................................... 1
3. BACKGROUND .................................................................................................................. 1
   a. Air Force Materiel Command (AFMC) .......................................................................... 2
   b. Air Force Test Center (AFTC) ........................................................................................ 2
   c. Arnold Engineering Development Complex (AEDC) .................................................... 2
   d. AEDC Test Operations Division (TOD) ......................................................................... 2
   e. McKinley Climatic Laboratory (MCL) ........................................................................... 2
   f. Air Makeup Unit 1 (AMU1) ............................................................................................ 3
   g. Reliance Test and Technology (RT&T) ......................................................................... 3
   h. Universal Fabricators, Inc. (Universal) ........................................................................... 4
   i. 96th Test Wing (96 TW) ................................................................................................. 4
4. SEQUENCE OF EVENTS ................................................................................................... 4
   a. Background on Work Performed at MCL AMU1 .......................................................... 4
   b. Day of the Mishap – 5 July 2017 .................................................................................... 7
      (1) Universal Employees ............................................................................................. 7
      (2) RT&T Employees ................................................................................................. 9
      (3) Emergency Response ............................................................................................. 9
5. MAINTENANCE ............................................................................................................... 12
   a. Maintenance Documents and Overview ....................................................................... 12
   b. Maintenance Forms ....................................................................................................... 12
   c. Scheduled Inspections ................................................................................................... 13
   d. Maintenance Procedures ............................................................................................... 13
   e. Unscheduled Maintenance ............................................................................................ 13
   f. Maintenance Personnel and Supervision ....................................................................... 13
6. EQUIPMENT, VEHICLES, FACILITIES, AND SYSTEMS ............................................. 13
   a. Structures and Systems ................................................................................................. 13
   b. Vehicles/Equipment ..................................................................................................... 14
   c. Evaluation and Analysis ............................................................................................... 15
7. ENVIRONMENTAL CONDITIONS ................................................................................ 15
   a. Forecast andObserved Weather .................................................................................. 15
   b. Other Environmental Conditions ................................................................................. 16
8. PERSONNEL QUALIFICATIONS ...................................................................................16
9. MEDICAL FACTORS .................................................................................................17
   a. Health and Injuries ............................................................................................17
   b. Pathology .........................................................................................................17
   c. Lifestyle ...........................................................................................................17
10. OPERATIONS AND SUPERVISION .......................................................................17
    a. Operations ......................................................................................................17
    b. Supervision ....................................................................................................17
       (1) Assessment of Condition of AMU1 Prior to 5 July 2017 ...........................17
       (2) Training & Procedures Related to Refrigerant .............................................19
11. GOVERNING DIRECTIVES AND PUBLICATIONS ..................................................20
    a. Publically Available Directives and Publications Relevant to the Mishap .......20
    b. Other Directives and Publications Relevant to the Mishap .............................20
    c. Known or Suspected Deviations from Directives or Publications ..................20
INDEX OF TABS ...........................................................................................................22
# ACRONYMS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>96 TW</td>
<td>96th Test Wing</td>
<td>Air Force Test Center</td>
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<tr>
<td>A&amp;E</td>
<td>Architectural and Engineering</td>
<td>EOG</td>
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<tr>
<td>AAFB</td>
<td>Arnold Air Force Base</td>
<td>EOH</td>
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<tr>
<td>AC</td>
<td>Air Conditioning</td>
<td>EOMS</td>
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<td>ACES</td>
<td>Automated Civil Engineer System</td>
<td>EOP</td>
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<td>AEDC</td>
<td>Arnold Engineering Development Complex</td>
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<td>AEGL</td>
<td>Acute Exposure Guideline Levels</td>
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<td>AFI</td>
<td>Air Force Instruction</td>
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<td>Base contracting execution division</td>
<td>FMC</td>
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<td>AHU</td>
<td>Air Handling Unit</td>
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<td>AKI</td>
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<td>ALCM</td>
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<td>CCSI</td>
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<td>CIV</td>
<td>Civilian</td>
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<tr>
<td>CMU</td>
<td>Concrete Masonry Unit</td>
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<td>COC</td>
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<td>EEOC</td>
<td>Eglin Emergency Operations Center</td>
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*McKinley Climatic Laboratory Mishap, Eglin Air Force Base, FL, 5 July 2017*
The above list was compiled from the Summary of Facts, the Index of Tabs, and Witness Testimony (Tab R and Tab V).

**PUEDONYMS**

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<td>Gov’t McKinley Climatic Lab Chief Installed Systems Test Flight</td>
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<td>Shelter in Place</td>
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<td>SOA</td>
<td>Shortness of Air</td>
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<td>SP</td>
<td>Security Police</td>
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<td>SUV</td>
<td>Sport Utility Vehicle</td>
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<td>Test Assembly</td>
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<td>TCA</td>
<td>Tri-Cyclic Antidepressants</td>
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<td>THC</td>
<td>Tetrahydrocannabinol (Marijuana)</td>
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<td>TN</td>
<td>Tennessee</td>
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<td>TOD</td>
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<tr>
<td>UAV</td>
<td>Unmanned Aerial Vehicle</td>
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<tr>
<td>UMD</td>
<td>Unit Manning Document</td>
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<td>USAF</td>
<td>United States Air Force</td>
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<td>Z</td>
<td>Zulu</td>
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McKinley Climatic Laboratory Mishap, Eglin Air Force Base, FL, 5 July 2017
SUMMARY OF FACTS

1. AUTHORITY AND PURPOSE

a. Authority

On 16 August 2017, Major General Warren D. Berry, Deputy Commander of Air Force Materiel Command (AFMC), appointed Colonel Travis C. Harsha to conduct a ground accident investigation of the 5 July 2017 mishap at the McKinley Climatic Laboratory (MCL) at Eglin Air Force Base (EAFB), Florida (FL). The ground accident investigation convened on 23 August 2017 in accordance with (IAW) Air Force Instruction (AFI) 51-503, Aerospace and Ground Accident Investigations. In addition to the board president, Col Harsha, board members included a legal advisor (Major), fire and emergency services member (Master Sergeant), facility maintenance member (Civilian), medical member (Major, physician), and recorder (Technical Sergeant).1

b. Purpose

In accordance with AFI 51-503, Aerospace and Ground Accident Investigations, this accident investigation board conducted a legal investigation to inquire into all the facts and circumstances surrounding this Air Force ground accident, prepare a publicly-releasable report, and obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative action.

2. ACCIDENT SUMMARY

On 5 July 2017, at about 9:55 a.m. local, a fire occurred in Air Makeup Unit 1 (AMU1) at Arnold Engineering Development Complex (AEDC) MCL on EAFB, FL, while a sub-contracted welder from Universal Fabricators, Inc. (Universal) was using an oxy-acetylene torch to remove a corroded structural I-beam on the east side of AMU1.2 The fire caused extensive damage to AMU1’s two sets of coils and adjacent Air Handling Unit (AHU), with an estimated government loss of approximately $30 million.3 Although at least 51 first responders or individuals on EAFB were exposed to smoke, only one individual required overnight medical observation and was discharged the next day without limitations.4

3. BACKGROUND

Located at EAFB, FL, and first used in 1947, MCL is part of the Test Operations Division (TOD), AEDC, Air Force Test Center (AFTC), AFMC.5 The MCL is the world’s largest environmental testing chamber and conducts testing for government and private industry.6 The MCL AMUs produce extreme temperature environments for engine testing.7

1 Tab Y-3.
3 Tab DD-3 to DD-7.
4 Tabs G-36 to G-37 and X-3 to X-5.
5 Tab CC-19 and CC-27.
6 Tab CC-41 to CC-47.
7 Tab CC-41 to CC-47.
a. Air Force Materiel Command (AFMC)

Headquartered at Wright-Patterson AFB, Ohio, AFMC conducts research, development, test and evaluation, and provides acquisition management services and logistics support necessary to keep USAF weapon systems ready for war.8

b. Air Force Test Center (AFTC)

Headquartered at Edwards AFB, California, AFTC is one of six subordinate centers of AFMC.9 AFTC leads the test and evaluation (T&E) mission, conducting developmental T&E and evaluation of air, space, and cyber systems to provide timely, objective, and accurate information to decision makers.10 AFTC oversees work carried out at multiple locations across AFMC, including EAFB, FL, and AEDC at Arnold AFB, Tennessee (TN).11

c. Arnold Engineering Development Complex (AEDC)

Headquartered at Arnold AFB, TN, AEDC is part of AFTC.12 With operating locations throughout the United States, including EAFB MCL, AEDC offers a suite of test capabilities to simulate speed, temperature, pressure and other parameters over a wide range to meet the needs of aerospace system developers.13

d. AEDC Test Operations Division (TOD)

Headquartered at Arnold AFB, TN, AEDC TOD includes MCL at EAFB, FL, and is responsible for programming, management, execution, and reporting all test and analysis and evaluation programs in AEDC’s wind tunnels, jet engine sea level and altitude test cells, ballistic ranges, arc heaters and other aerospace test units.14

e. McKinley Climatic Laboratory (MCL)

Located at EAFB, FL, and first used in 1947, MCL (Building 440) is an AEDC TOD facility, providing government and private industry with chambers able to simulate any climatic environment in the world to ensure maximum reliability and operational capability of complex systems.15 MCL has five testing chambers: the Main Chamber; the Equipment Test Chamber;

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8 Tab CC-3.
9 Tab CC-11.
10 Tab CC-11.
11 Tab CC-11.
12 Tab CC-14.
13 Tab CC-14.
14 Tab CC-37.
15 Tab CC-40 to CC-55.
the Sun, Wind, Rain, and Dust Chamber; the Salt Fog Chamber; and the Altitude Chamber.\(^\text{16}\) The Main Chamber is the largest environmental chamber in the world.\(^\text{17}\) The Main Chamber and Equipment Test Chamber have the capability to maintain temperatures from -65\(^\circ\) to 165\(^\circ\) Fahrenheit (F) and can simulate all climatic conditions including snow, rain, wind, and sand.\(^\text{18}\)

**f. Air Makeup Unit 1 (AMU1)**

Built in 1968, AMU1 is one of MCL’s two AMUs used for climatic testing (See Figure 1).\(^\text{19}\) During engine testing, the air makeup system replaces exhausted air from the engines. The air temperature is controlled using coils containing a solution of calcium chloride (CaCl\(_2\), basically salt water), coils containing a solution of methylene chloride (R-30, a refrigerant), and a boiler system that produces steam.\(^\text{20}\) When testing requires temperature fluctuations, a variable-speed fan blows outside air over the coils while pumps circulate the air over the steam coils to generate heat while the salt water coils dehumidify the steam coils.\(^\text{21}\) The refrigerant coils produce cold temperatures or regulate the temperature from the boiler and salt water coils.\(^\text{22}\) When the air reaches the desired temperature, it is transferred to the test chamber via an AHU.\(^\text{23}\) AMU1 is located in the southwest portion of the MCL Facility.\(^\text{24}\)

**g. Reliance Test and Technology (RT&T)**

Headquartered at Fort Walton Beach, FL, RT&T was established in July 2015 when InDyne, Inc. and URS merged.\(^\text{25}\) RT&T has several contracts with the USAF and other government and commercial customers.\(^\text{26}\) In February 2016, the USAF awarded RT&T a contract, which InDyne, Inc. previously held, to provide operations and maintenance (O&M) services at multiple USAF facilities, including MCL, starting 1 October 2016.\(^\text{27}\)

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\(^{16}\) Tab CC-27 to CC-41.

\(^{17}\) Tab CC-27 to CC-41.

\(^{18}\) Tab CC-40 to CC-55.

\(^{19}\) Tabs CC-51 to CC-52, Z-49, and Z-129 to Z-133.

\(^{20}\) Tabs CC-41, CC-51 to CC-52, V-3.10, V-5.4, V-10.12, and V-12.10.

\(^{21}\) Tab CC-51 to CC-52.

\(^{22}\) Tab CC-51 to CC-52.

\(^{23}\) Tab CC-51 to CC-52.

\(^{24}\) See Figure 1. Tab Z-49.

\(^{25}\) Tab CC-56.

\(^{26}\) Tab CC-56.

\(^{27}\) Tabs O-141 to O-143, V-12.3, V-12.9, V-21.12 to V-21.13, V-33.3, and CC-56.
h. Universal Fabricators, Inc. (Universal)

Headquartered at Cantonment, FL, Universal was established in 1985 and is licensed in Florida and Alabama to provide contracted support for all piping and structural steel fabrication, field erection, and installation via a design, installation, and start-up program designed for a complete turn-key operation. On 26 April 2017, RT&T sub-contracted with Universal to replace portions of AMU1’s corroded structural support, with work starting on 19 June 2017 and continuing to the day of the mishap.

i. 96th Test Wing (96 TW)

The 96 TW is the test and evaluation center for USAF air-delivered weapons, navigation and guidance systems, Command and Control systems, and Air Force Special Operations Command systems. As the host wing for EAFB, the 96 TW has responsibility for base support functions and overall installation command. Prior to 1 December 2016, MCL was assigned to the 96 TW.

4. SEQUENCE OF EVENTS

a. Background on Work Performed at MCL AMU1

On 26 February 2014, MCL and RT&T (previously named InDyne, Inc.), determined the AMU1 structural support I-beams needed replacement due to corrosion caused by the salt water used in AMU1 and submitted a work order to the 96 TW Civil Engineer (CE) squadron. Since the AMU1 corrosion caused the coils to sag, several RT&T employees raised concerns about working in the elevated areas of AMU1 and working alone inside AMU1.

On 12 May 2016, when the structural replacement work had not occurred, RT&T employees notified the MCL Chief (MCLC) of the increasingly corroded conditions of AMU1, including a heavily corroded structural I-beam that held up the second level of coils. To address this, MCLC (a mechanical and aeronautical engineer) had RT&T place additional support beams in AMU1 in the summer of 2016 to prevent the structure from collapsing.

Between late December 2016 and 12 January 2017, a 96 TW CE Project Manager (CE2) contacted MCLC regarding the 2014 CE work order. Subsequently, MCLC scheduled a 13 January 2017 walk-through of AMU1 with CE2 and a 96 TW CE Structural Engineer (CE3) to discuss the work.

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28 Tab CC-58.
29 Tabs O-3 to O-10, O-20, V-12.7, and V-12.13.
30 Tab CC-59.
31 Tab CC-59.
32 Tab CC-69 to CC-77.
33 Tab U-34 to U-39. RT&T performs small-scale welding projects at MCL but brings in a sub-contractor for large-scale projects, such as the AMU1 corrosion control project. Tab V-10.2 and V-11.1.
34 Tab V-17.24, V-21.17 to V-21.18, and V-23.4 to V-23.5.
35 Tabs V-36.1 to V-36.2, V-37.5 to V-37.6, and Z-45 to Z-48.
36 See Figure 20. Tab V-35.9, V-36.1 to V-36.3, and V-37.5 to V-37.6.
order and show CE2 and CE3 the additional AMU1 support beams he installed the previous summer.\textsuperscript{38}

Given the increased corrosion in AMU1, MCLC requested to accomplish the work through the Contract by Requestor (CBR) process, an expedited contract approval method used when the requested project is within the technical capacity of the requesting entity, such that CE can serve as technical support for the execution.\textsuperscript{39} On 14 February 2017, CE approved the CBR work order request for corrosion control at AMU1.\textsuperscript{40}

On 13 April 2017, RT&T received government approval to contract for the needed structural support work at AMU1.\textsuperscript{41} On 26 April 2017, RT&T signed a contract with Universal to perform the work.\textsuperscript{42}

In general, the contract between RT&T and Universal required: 1) the removal and replacement of two lower support beams, one on the east and one on the west side, of AMU1; 2) the demolition and replacement of all piping coming from the salt water coils in AMU1; and 3) the replacement of all structural steel, corrugated metal and insulation up to 26 feet elevation inside and outside the east and west sides of AMU1 directly in front of the salt water (CaCl2) and refrigerant (R-30) coils (See Figures 2 and 3).\textsuperscript{43}

The Universal general manager (UGM), who entered into the contract, believed only the salt water coils would be drained, while the Universal Foreman (UWF) and Universal Welders (UWs) believed that the salt water and refrigerant coils would be drained prior to starting work and continued to believe both sets of coils were in fact drained for about a week after starting work until RT&T informed them otherwise.\textsuperscript{44} RT&T did not drain the refrigerant coils because

\textsuperscript{38} Tabs BB-253 to BB-254.
\textsuperscript{39} Tab V-38.5, V-39.6, and V-40.3.
\textsuperscript{40} Tabs V-39.15 and BB-267.
\textsuperscript{41} Tab AA-27.
\textsuperscript{42} Tab O-3 to O-4.
\textsuperscript{43} Tab O-5 to O-7.
\textsuperscript{44} Tabs O-7, R-122, R-129, R-143 to R-144, V-6.3, V-7.3, V-12.6, and V-13.3.
Universal was not planning to work directly on them, other than replacing the support beams holding up the refrigerant coils.\textsuperscript{45} RT&T employees at MCL differed in their recollection of the procedures to drain the refrigerant coils and how long it would take to drain the refrigerant coils.\textsuperscript{46}

On 19 June 2017, Universal began work on AMU1 after 96 TW Deputy Fire Chief (DFC1) issued a permit to UWF that allowed cutting and grinding using a heat source to remove an I-beam.\textsuperscript{47} The permit stated Universal was to remove combustibles before work and operations using a heat source were not to be performed on containers or pipes containing combustibles.\textsuperscript{48}

About a week after Universal started work at MCL, the RT&T MCL Safety Lead (RTTSE1) notified UW1 and UW6 to be careful because: the R-30 refrigerant coils were not drained; the refrigerant was dangerous to breathe; refrigerant leaks could be identified by smell; if you smelled refrigerant you had already been overexposed; that a leak should be reported immediately to the MCL control room; and to share this information with the rest of the Universal crew, which they did.\textsuperscript{49} RTTSE1 did not inform the UWs about the flammability of the refrigerant.\textsuperscript{50}

After receiving the refrigerant safety precautions mentioned above and removing corrugated metal and insulation from the side of AMU1 during the first week of work at MCL, the UWs installed plywood over both the salt water and refrigerant coils to protect them from damage (See Figures 4 and 5).\textsuperscript{51}

The R-30 refrigerant is stable at room temperatures and pressures, but can ignite if heated and should avoid high temperatures, open flames, sparks, and other ignition sources.\textsuperscript{52} The refrigerant has an auto-ignition temperature of 1,033° F and, in vapor form, can ignite at 212° F.\textsuperscript{53} An oxy-acetylene torch can heat material being cut to temperatures up to 1,600° F and can generate sparks for several feet surrounding the area of the cut.\textsuperscript{54} Although AMU1 contained non-flammable Foamglas® insulation on the piping and walls, the insulation required adhesives, sealants, and coatings that were flammable and could produce dense smoke when burned.\textsuperscript{55}

\textsuperscript{45} Tab R-87 to R-88.
\textsuperscript{47} Tabs O-20, R-67 to R-68, AA-49, V-2.1, and V-7.4 to V-7.5.
\textsuperscript{48} Tabs O-20 and AA-49.
\textsuperscript{49} Tabs R-41, R-54, R-122, V-6.3 to V-6.5, V-7.5 to V-7.7, V-19.9 to V-19.11, and V-41.2 to V-41.3.
\textsuperscript{50} Tabs R-41, R-54 to R-55, R-116, R-122, V-6.3 to V-6.5, V-7.5 to V-7.7, V-19.9 to V-19.11, and V-41.2 to V-41.3.
\textsuperscript{51} Tabs R-54, R-117 to R-118, R-123, V-6.4, V-12.9, V-31.3, and V-43.6.
\textsuperscript{52} Tab BB-6.
\textsuperscript{53} Tabs O-46 and AA-7.
\textsuperscript{54} See Figure 9. Tabs Z-81 to Z-82, and CC-79.
\textsuperscript{55} Tabs O-57, U-68 to U-70, U-73 to U-74, U-76 to U-77, U-81, U-84, U-91, U-93 to U-95, and V-14.15.
b. Day of the Mishap – 5 July 2017

(1) Universal Employees

Starting at 6:30 a.m. on 5 July 2017, on the east side of AMU1 (See Figure 6), UW1 and UW2 took turns using an oxy-acetylene torch to cut out remaining portions of a structural steel I-beam running horizontally between the first and second levels of coils in AMU1 while in an electronic lift (See Figure 7).

At 9:00 a.m., the UWs and UWF took a break together that ended at about 9:15 a.m. After the break, UW1 resumed using the oxy-acetylene torch, the only heat source used after the break, to cut out the remaining two feet of the backside of a steel I-beam between the first and second levels of AMU1 next to the refrigerant (R-30) coils (See Figure 7).

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56 At the time of the fire, UWF was unable to see the work at AMU1 and UW3 was operating non-welding equipment such as air compressors and a forklift. Tabs R-37 to R-39 and V-31.
57 Tab R-120 to R-121.
58 Tab R-103 and R-113.
Figures 7 to 9). The I-beam being cut was approximately two and a half inches from the face of the coils (See Figure 8).

While cutting with the oxy-acetylene torch, UW1 recalls using plywood to protect the coils from sparks.

While UW1 was cutting, UW2 was on the ground watching UW1 while disposing of material cut out of the east side of AMU1.

On the west side of AMU1, prior to the 9:00 a.m. break, UW4 and UW5 were using welding tools on a platform to replace a door frame between the coils. After the break, UW4 and UW5 were on the ground outside AMU1 on the west side discussing how to attach the new door frame (See Figure 10). That discussion continued until approximately 9:55 a.m., when UW4 and UW5 saw heavy black smoke pouring out between the coils on the west side of AMU1 and heard hissing noises that sounded like the release of pressurized air. As UW4 ran slightly inside of AMU1, he saw AMU1’s ceiling dripping with sparks and filled with black smoke that appeared to be coming from the north side of AMU1 towards the AHU, which is padded with insulation.

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59 Tabs R-38 to R-39, R-44, R-51 to R-52, and R-122.
60 Tab Z-77 to Z-78.
61 Tab R-123.
62 Tab R-39, R-44, and R-51 to R-52.
63 Tabs R-13 to R-14, R-27, R-100, V-9.6, and V-43.5.
64 Tabs R-13, R-17, R-100, R-111, and V-43.5.
65 Tabs R-17, R-28 to R-29, R-100, R-111 to R-112, and V-9.8.
After seeing the fire, UW4 and UW5 ran through AMU1 to the UWs on the east side of AMU1 to warn them and clear them from the area.⁶⁶ On hearing yells of “fire,” UW2 saw black smoke rolling down from the top of AMU1 and also heard what sounded like the release of pressurized air.⁶⁷ UW1 lifted his welding face shield and saw thick black smoke.⁶⁸

(2) RT&T Employees

On 5 July 2017, two RT&T employees were working at AMU1, but both left the facility prior to the time the UWs saw the fire and neither did work using a heat source.⁶⁹ That morning, before the mishap, an RT&T Welder (RTTW1) used an electronic lift (different than the lift used by Universal) on the east side of AMU1 to remove insulation from a valve and pipe on the top of AMU1.⁷⁰ Another RT&T welder (RTTW2) checked the work of RTTW1 while the UWs were on their 9:00 a.m. break and then came down off AMU1 prior to the fire.⁷¹

(3) Emergency Response

At 9:57 a.m., the UWs and UWF alerted RT&T employees, who radioed internally at MCL that there was a fire, and the RT&T Facility Manager (RTTFM) ordered an evacuation of the MCL via the loudspeaker system and called 911.⁷² Many EAFB personnel called 911 after seeing a thick cloud of black smoke rising from MCL (See Figure 11).⁷³

Following the 911 call, MCLC, RTTFM, and UGM determined that everyone had safely evacuated.⁷⁴ Between 9:59 a.m. and 10:01 a.m., 96 TW Fire Response arrived at MCL, reported all facility occupants accounted for, per RTTFM and UGM, and began fighting the fire.⁷⁵ At about 10:00 a.m., ambulances were on-scene.⁷⁶

DFC1 assumed the role of Incident Commander, established a 1,000-foot cordon around MCL, ordered a shutdown of heating, ventilation, and air conditioning systems, and a shelter-in-place for EAFB personnel in the path of the smoke.⁷⁷

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⁶⁶ Tabs R-17, R-36, R-50, and V-43.4.
⁶⁷ Tabs R-50 and R-55.
⁶⁸ Tab R-121.
⁶⁹ Tab V-10.7, and V-11.1 to V-11.2.
⁷⁰ Tab V-6.10, V-7.11, V-10.7, and V-11.1 to V-11.2.
⁷¹ Tab V-7.11, V-10.7, and V-11.1 to V-11.2.
⁷² Tabs N-14, R-4, and R-83.
⁷³ Tab N-14.
⁷⁴ Tabs R-128, V-4.1 to V-4.2, and V-13.1.
⁷⁵ Tab N-14 and N-18.
⁷⁶ Tab N-19 and N-24.
⁷⁷ Tabs N-2, N-21, R-62, and AA-58.
By 10:04 a.m., the acrid nature of the smoke led firefighting personnel to believe there was a chemical compound adding to the fire, and after several firefighters experienced a burning sensation under their regular suits, the firefighters began to withdraw and decontaminate. DFC1 assumed the chemical causing the discomfort was the refrigerant after reviewing AMU1 pre-planning documents, which listed all hazards that may be encountered during emergency response at MCL. Firefighter personnel donned additional protective gear against the refrigerant and resumed fighting the fire without further issue.

By 10:18 a.m., the 96 TW Fire Chief (FC), who was on-duty but off-base when the fire began, called civilian firefighting crews from nearby cities to the scene to provide additional manpower and equipment. In addition, civilian hazardous materials personnel were called to the scene due to the presence of the refrigerant. At about 10:30 a.m., civilian firefighting crews arrived at MCL.

By 11:07 a.m., although still burning, the fire was under control.

At 3:44 p.m., DFC1 re-confirmed through 96 TW Bioenvironmental (BE) that R-30 refrigerant was burning and present in soil, air, and water samples. By 6:09 p.m., the fire was nearly out with hot spots cooled, and by 7:09 p.m., the firefighters secured the scene and departed.

The fire caused extensive damage to AMU1’s two sets of coils and adjacent AHU and attached insulation, with an estimated government loss of approximately $30 million (See Figures 12 to 15). FC determined there were about 4,000 gallons of refrigerant consumed by the fire.

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**Figure 12:** AMU1 Fire Chief Diagram (Tab S-53)
FC recalled speaking with one of the UWs during the emergency response, who said the fire began when UWs were cutting old rusted metal with a torch and liquid began leaking out of a pipe, hit the hot metal, and fire began running up a pipe. The UWs do not recall this conversation.

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Tab R-76 and R-78.
Tab V-7.8 to V-7.9, V-31.8, V-41.5, and V-43.7 to V-43.8.
UW4 recalls sitting in a fire department vehicle with what he believed to be a Fire Chief but does not recall a conversation about the cause of the fire.\textsuperscript{91}

A 96 TW Fire Department investigation determined the probable cause of the fire was direct welding flame contact with a flammable chemical (methylene chloride).\textsuperscript{92}

5. MAINTENANCE

a. Maintenance Documents and Overview

The RT&T O&M responsibilities at MCL include management for all MCL equipment and facilities.\textsuperscript{93}

The biggest maintenance issues at AMU1 were leaks and corrosion caused by the salt water.\textsuperscript{94} The salt water corrosion led to major corrective renovations in 1990 (replacing concrete support structure with steel supports and corrugated metal panel siding), 1993 (upgrading electrical support systems), and 2002-2003 (replacing salt water coils).\textsuperscript{95}

The AMU1 refrigerant coils only had two formally reported leaks from 2012-2017, one in 2013 and one in 2014.\textsuperscript{96} Although all leaks must be documented and reported and there were no documented leaks of refrigerant in 2015-2017, there were several small refrigerant leaks not documented.\textsuperscript{97}

b. Maintenance Forms

RT&T’s maintenance system generates task instructions and work orders for scheduled inspections and maintenance, and the Facility Problem Report (FPR) indicates any discrepancies found during formal inspections through maintenance work orders or in routine preparation for testing.\textsuperscript{98} RT&T FPR logs included entries in 2016 and 2017 for the Universal project.\textsuperscript{99}

\textsuperscript{91}Tabs R-100 to R-101 and V-9.8 to V-9.9.
\textsuperscript{92}Tab AA-45 to AA-46.
\textsuperscript{93}Tab O-168.
\textsuperscript{94}Tab D-34 to D-45.
\textsuperscript{95}Tabs V-12.3, V-13.2, and Z-129 to Z-154.
\textsuperscript{96}Tab D-45.
\textsuperscript{97}Tabs D-45, V-5.8 to V-5.9, V-14.13 to V-14.16, V-21.15, V-28.4, and U-32. An RT&T AMU Operations Specialist (RTTAMUOS) was not aware of any refrigerant leaks in the last 10 years and stated that if there had been leaks he would have been aware of them and notified RTTFM. Tab V-17.8 and V-17.15. RTTSE2 was not aware of AMU1 having refrigerant leaks and stated that RT&T safety is aware when there is a leak. Tab V-15.8 to V-15.9. RTTSE1 recalled a couple of minor leaks of refrigerant and stated that he should be notified of any leaks. It is unknown if the leaks recalled by RTTSE are the documented 2013 and 2014 leaks. Tab V-19.12. An RT&T Air Conditioning Field Engineer (RTTACFE) stated the most recent leak of refrigerant was in early 2017 on top of the south side of AMU1 and that the refrigerant dripped onto and melted the surrounding asphalt. Tab V-14.13. While RTTACFE stated he repaired the leak, he does not believe the leak was documented because “some work doesn’t get through the system.” Tab V-14.14. In addition, RTTACFE stated that in the past year there was a second leak of refrigerant in AMU1 that dripped onto and melted Foamglas® insulation. Tab V-14.15. RTTACFE stated that RTTFM was aware of these leaks. Tab V-14.14 and V-14.16.
\textsuperscript{98}Tab U-6 to U-33.
\textsuperscript{99}Tab D-42 to D-43.
c. Scheduled Inspections

RT&T’s maintenance task instructions for AMU1 indicate there were scheduled inspections and maintenance performed for both the salt water and refrigerant coils in June 2017 with no discrepancies noted.100

d. Maintenance Procedures

RT&T performs inspections and maintenance (scheduled and unscheduled) IAW work instructions, listing discrepancies on an FPR and log.101 If discrepancies affect real property or 96 TW CE needs to review the work, a work order is submitted.102 In February 2014, RTTFM (then under InDyne, Inc.) submitted a CE work order for corrosion control efforts at AMU1.103

e. Unscheduled Maintenance

RT&T documents unscheduled maintenance on an FPR log as discrepancies found during inspections and maintenance or test preparation.104 From 2012-2017, nine FPR entries were related to the AMU1 refrigerant system, with only two reported leak issues, one in 2013 and one in 2014.105

f. Maintenance Personnel and Supervision

RTTFM supervises RT&T maintenance personnel.106 MCL maintenance personnel, all of whom are RT&T employees except for one independent contractor, have extensive experience ranging from 5 to 30 years working with the MCL systems.107 RT&T maintains and documents training and certification for maintenance tasks, including annual requirements such as equipment operation, safety items (confined space, first aid, and respirator), procedures for work requiring the use of a heat source and other facility specific training.108

6. EQUIPMENT, VEHICLES, FACILITIES, AND SYSTEMS

a. Structures and Systems

Built in 1968, AMU1 is composed of a fan room, motor control room, condensate return room, and coil room.109 The AMU1 coil room contains three banks of copper coils in a closed-loop system.110 The coils sit on a carbon steel support structure.111 The first bank of coils is adjacent

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100 Tab D-12 to D-45.
101 Tab U-6 to U-33.
102 Tab V-29.6 to V-29.7 and V-37.2.
103 Tab U-34 to U-39 and U-104 to U-105.
104 Tab U-12 to U-14.
105 Tab D-45.
106 Tab V-5.3.
108 Tab G-30 to G-35.
109 Tabs S-53 and Z-130.
110 Tabs V-3.11, V-5.3 to V-5.4, V-14.18, V-21.18, and Z-129 to Z-144.
111 Tab Z-136 to Z-137.
to the fan room on the input side and are steam coils fed from on-site boilers.\textsuperscript{112} The second bank of coils contains 16 coils with salt water (CaCl\textsubscript{2}), and the next two banks each contain 16 refrigerant (R-30) coils (See Figure 16).\textsuperscript{113} The AMU1 walls are insulated with 5” panels of Foamglas\textsuperscript{®} insulation.\textsuperscript{114} Supply and return piping to the coil systems are external to the building with flexible connectors insulated with Foamglas\textsuperscript{®} and coated with a tar-based product wrapped in an aluminum sleeve.\textsuperscript{115}

Due to extremes in routine operating temperatures in AMU1, there was no fire alarm, automatic fire suppression system, or refrigerant leak detection in the coil room.\textsuperscript{116}

At the time of the mishap, the walls of AMU1 were in serviceable condition with the exception of the metal siding panels at both the east and west side near the salt-water coils.\textsuperscript{117} The supply and return piping and the steel support structure for the coils was extremely corroded due to the salt water.\textsuperscript{118}

\textbf{b. Vehicles/Equipment}

There were three pieces of equipment involved in the mishap.\textsuperscript{119}

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\textsuperscript{112} Tabs S-54 and Z-139.
\textsuperscript{113} Tabs S-54 and Z-139.
\textsuperscript{114} Tabs V-14.15 and Z-134 to Z-144.
\textsuperscript{115} Tab V-5.11, V-14.15, V-14.18, and V-14.20.
\textsuperscript{117} Tab Z-3 to Z-4 and Z-35 to Z-36.
\textsuperscript{118} Tab Z-3 to Z-48.
\textsuperscript{119} Tab U-60 to U-66.
Oxy-Acetylene Tanks and Torch: UW1 and UW2 used Universal’s tanks and torch to cut the I-beam on the east side of AMU1.\footnote{Tabs R-38 to R-39, R-52, R-121 to R-122, and V-41.7.} When the fire started, UW2 and UWF shut off and pulled the tanks away from the building.\footnote{Tab R-43 to R-44 and R-56.}

Manlift: Universal rented the manlift.\footnote{Tab U-60 to U-61.} At the time of mishap, UW1 was using the lift to reach the I-beam being cut with the torch.\footnote{See Figure 7. Tab R-121.} The last routine maintenance on the lift was on 19 December 2016 and the annual inspection on the lift was completed 3 March 2017.\footnote{Tab U-61.}

Welding Machine: Universal rented the welding machine.\footnote{Tab U-60 and U-62.} The last routine maintenance on the welding machine was on 30 May 2017 and the last preventive maintenance on the welding machine was completed on 15 March 2016.\footnote{Tab U-62.} Prior to Universal starting work at AMU1 on 19 June 2017, RT&T cut off the power to AMU1 where the work was to occur.\footnote{Tab V-23.3.} Therefore, on the east side of AMU1, the UWs were using the rented welding machine as a power source as well.\footnote{Tabs R-53 and V-41.4.} On the west side of AMU1, the UWs were getting power for cooling fans and lights from extension cords plugged into both an electrical room adjacent to the west side of AMU1 and the diesel-powered portable welding machine on the east side of AMU1.\footnote{Tabs R-30, R-102, and R-114 to R-115.} UW4 used extension cords from the diesel-powered welding machine located on the east side of AMU1 on the day of the mishap prior to taking the 9:00 a.m. break.\footnote{Tab R-102 and R-115.}

c. Evaluation and Analysis

All equipment and extension cords were functioning properly on 5 July 2017.\footnote{Tabs D-2 to D-33 and U-61 to U-66.}

7. ENVIRONMENTAL CONDITIONS

a. Forecast and Observed Weather

The observed weather at EAFB at 9:55 a.m. on 5 July 2017 was 87.6° F with a heat index of 96.7° F, 65% humidity, and a calm wind. By 10:55 a.m., the temperature had risen to 88.3° F with a heat index of 97.4° F, 63% humidity, and wind that frequently changed direction at 5.8 miles per hour (mph). By 2:55 p.m., the temperature was 89.6° F with a heat index of 99.3° F, 61% humidity, and a wind out of the south-southwest at 11.5 mph.\footnote{Tab W-3 to W-6.} At the beginning of the day, the wind changed direction several times, but by 12:00 p.m., the wind was coming from the south or southwest.\footnote{Tabs N-20 to N-27, R-62, and W-3 to W-6.}
b. Other Environmental Conditions

The AMU1 layout created several difficulties when fighting the fire. AMU1 is located in a lowered embankment and surrounded by chemical tanks on the southeast and southwest sides so fire fighters had to cut a portion of a fence on the east side and weave fire hoses underneath tanks and pipes to fight the fire.

During the fire, approximately 4,000 gallons of R-30 (methylene chloride) refrigerant was in the AMU1 coils. On 5 and 6 July 2017, 96 TW Bioenvironmental (BE) tested soil, air, and water samples taken in the immediate vicinity of AMU1 and the concentration of refrigerant found in the samples indicated that exposure in that area could cause temporary discomfort, irritation, or non-sensory effects that would be reversible upon termination of exposure (See Figure 17).

<table>
<thead>
<tr>
<th>Date</th>
<th>Type of Sample</th>
<th>Location</th>
<th>Results for Methylene Chloride</th>
<th>AEGL 1 (Negligible Health Effects)</th>
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<tr>
<td>5 Jul</td>
<td>Soil</td>
<td>Dead Vegetation 1</td>
<td>Positive</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Soil</td>
<td>Dead Vegetation 1</td>
<td>Positive</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Soil</td>
<td>Dead Vegetation 2</td>
<td>Positive</td>
<td>N/A</td>
</tr>
<tr>
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<td>Pond</td>
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<tr>
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<td></td>
<td>Water</td>
<td>Coils</td>
<td>Positive</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Figure 17: 96 TW BE R-30 Refrigerant Test Results, 5-6 July 2017 (Tab O-97)

No other relevant environmental conditions were noted.

8. PERSONNEL QUALIFICATIONS

On 5 July 2017, all Universal and RT&T personnel working at AMU1 were qualified for their respective positions and had up-to-date credentials.
9. MEDICAL FACTORS

a. Health and Injuries

After the accident, the UWs were not in need of medical treatment or treated by medical personnel.\textsuperscript{139} There were no indications that the UWs were in any condition other than their usual state of health prior to the mishap.\textsuperscript{140}

The medical records of 45 individuals near AMU1 at the time of the mishap were reviewed.\textsuperscript{141} These individuals were either first responders or bystanders in the vicinity of AMU1 at the time of the mishap.\textsuperscript{142} Only one individual is known to have required admission to the hospital for observation and that individual was discharged the following day without limitations.\textsuperscript{143} Per available medical records, no other individuals required hospital admission because of this mishap. Those requiring medical attention had symptoms related to methylene chloride (R-30 refrigerant) exposure, smoke inhalation, and/or dehydration secondary to heat exposure.\textsuperscript{144}

b. Pathology

This item is not applicable, as there were no fatalities.

c. Lifestyle

There is no evidence that lifestyle was a factor in the accident.\textsuperscript{145}

10. OPERATIONS AND SUPERVISION

a. Operations

While MCL is a high-demand facility, the work on AMU1 was scheduled for June to September 2017 due to a gap in testing that did not require the use of AMU1.\textsuperscript{146}

b. Supervision

(1) Assessment of Condition of AMU1 Prior to 5 July 2017

The work at AMU1 was contracted for via CBR, which has a faster governmental approval time.\textsuperscript{147} In 2017, prior to the work on AMU1, the facility was evaluated for whether a RAC applied that

\begin{itemize}
  \item Tab X-3 and X-6.
  \item Tab X-3.
  \item Tab X-3.
  \item Tab X-3.
  \item Tab X-3.
  \item Tab X-3 to X-6.
  \item Tabs G-2 to G-12 and X-3 to X-5.
  \item Tabs R-87 and AA-27.
  \item Tab V-38.4 to V-38.5 and V-39.7.
\end{itemize}
could elevate the priority of the CE work request. RACs are a rating system used, in part, to prioritize work requests by evaluating the facility’s mishap/hazard potential.

For CBR projects, CE serves as technical support for the execution of the work. However, in the case of the work at AMU1, CE3 (a structural engineer), was not notified prior to the work starting, did not review the work requested, and did not review any documents or perform support calculations for AMU1.

On 1 February 2017, MCLC, three 96 TW BSE members (BSE1, BSE2, and SIBIO/BSE3), RTTFM, and the RT&T Contract Safety Representative (RTTSE2) performed a walk-through of AMU1. During this walk-through, SIBIO/BSE3 and RTTSE2 took photographs (See Figures 18 and 19).

After the walk-through, BSE informed MCLC that BSE could apply a RAC if MCLC desired but the RAC-level BSE would assign would not cause CE to elevate the status of the requested work so MCLC indicated he would continue to pursue a CBR to accomplish the requested work.

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148 Tabs V-25.3, V-25.18, V-34.4, and BB-85 to BB-86.
149 Tab BB-48 to BB-49. In 2014, the requested work on AMU1 was marked “not competitive” for funding with the comment that there was no consequence or probability of failure (the very criteria a RAC measures) included with the work request. Tab U-35 and U-38.
150 Tab V-38.5.
151 Tab V-38.10, V-39.15 to V-39.16, V-40.6, V-40.8 to V-40.10. In fact, after the 13 January 2017 AMU1 walk-through with MCLC, CE3 believed the work requested on AMU1 was a complete removal and replacement of all structural support on the facility rather than support work only on the lower levels of AMU1. Tab V-40.3 to V-40.4. In CE3’s opinion, removing only the lower structural support I-beams without additional support could cause a shift in the coils. Tab V-40.9 to V-40.10. Additionally, CE3 did not believe people were working in AMU1 and was of the opinion that people should not be working in AMU1 due to its condition. Tab V-40.11.
152 Tab V-15.9, V-25.2, V-34.3, and V-35.2. The day prior to the walk-through, MCLC invited CE3 and stated that if CE3 was unable to attend, he would contact him after the walk-through. Tab BB-265. Although CE3 was unable to attend the walk-through, MCLC and BSE never contacted CE for an assessment of severity of probability of risk due to the condition of AMU1 during the evaluation of whether to apply a RAC to the facility. Tab V-39.9 and V-40.9.
153 Tabs V-16.1 to V-16.19, Z-3 to Z-37, and Z-38 to Z-44.
154 Tabs V-25.3, V-25.7, V-25.18, V-34.4, and BB-85 to BB-86. During the walk-through, MCLC stated that he already had CBR funding for the AMU1 project but the issue was finding time to accomplish the work. Tab V-25.16 to V-25.18.
Prior to being employed by RT&T, RTTSE2 was an active-duty USAF member assigned to flight safety, and although he did not assign RACs, he was familiar with the RAC process.\textsuperscript{155} RTTSE2 believed AMU1 should have been assigned a RAC and shut down.\textsuperscript{156} While BSE1 and BSE2 do not recall anyone other than BSE personnel discussing an opinion of whether a RAC applied to AMU1, RTTSE2 recalled a discussion during the walk-through that a high level RAC would shut down AMU1 and that he made known to those on the walk-through that a high-level RAC should be assigned.\textsuperscript{157} During the discussion of a high-level RAC shutting down AMU1, RTTSE2 recalls the conversation changing away from assigning a high-level RAC to avoid shutting down AMU1.\textsuperscript{158}

No RAC was assigned to AMU1.\textsuperscript{159}

On 5 April 2017, Universal submitted their final quote for the work on AMU1, the work originally requested by MCL in 2014.\textsuperscript{160} On 13 April 2017, a technical directive was approved for the work on AMU1.\textsuperscript{161} On 25 April 2017, RT&T entered into a contract with Universal to perform the work on AMU1.\textsuperscript{162}

\textbf{(2) Training & Procedures Related to Refrigerant}

Between 2 to 4 years prior to 5 July 2017, RTTFM verbally assigned RTTSE1 as the primary MCL Safety Representative, however, RTTSE1 received no training upon appointment as safety representative.\textsuperscript{163} Furthermore, when interviewed, RTTSE1 believed the primary safety representative at MCL was RTTFM.\textsuperscript{164}

RT&T’s MCL training materials on the refrigerant says it is not flammable.\textsuperscript{165} RTTSE1 believes the training was last given about 10 years ago and recalls asking RTTFM to give the training again due to several new employees at MCL needing the information, but to his knowledge, the training was not given again.\textsuperscript{166} Both MCLC and RTTFM believed the R-30 refrigerant was not flammable.\textsuperscript{167}

\textsuperscript{155} Tab V-16.16 to V-16.17.
\textsuperscript{156} Tab V-15.9, V-15.16, V-16.16 and V-16.17.
\textsuperscript{157} Tab V-15.10, V-16.18, V-25.9, V-25.16, and V-34.16.
\textsuperscript{158} Tab V-16.16. On 6 February 2017, MCLC emailed BSE “after you described the RAC process to me, I strongly suggest that we don’t go that route and elevate this all the way to MAJCOM [AFMC]” and instead recommended the project be accomplished via CBR. Tab BB-86.
\textsuperscript{159} Tabs V-25.7, BB-82 and BB-90.
\textsuperscript{160} Tab O-6 to O-7 and Tab U-34 to U-39.
\textsuperscript{161} Tab AA-27.
\textsuperscript{162} Tab O-3 to O-4.
\textsuperscript{163} Tab V-5.14 to V-5.15 and V-19.3 to V-19.4.
\textsuperscript{164} Tab V-5.14 and V-19.18.
\textsuperscript{165} Tab AA-6.
\textsuperscript{166} Tab V-19.6.
\textsuperscript{167} Tabs R-7 and V-3.5.
RT&T is responsible for briefing subcontractors working at MCL on safety matters related to the facility and RT&T’s Environmental Safety and Occupational Health Administrator for the entire RT&T contract (RTTSE3), states subcontractors at AMU1 are briefed on the refrigerant by RTTFM or RTTSE1.\textsuperscript{168} RTTSE1 was unaware of a pre-work meeting with Universal and briefed UWs and UWF approximately a week after they started working on the hazards of the refrigerant but did not mention flammability.\textsuperscript{169}

Additionally, contractors working at MCL must be told where designated smoking areas are upon checking in at the front desk, although there is no written procedure or brief given on designated smoking areas (See Figure 20).\textsuperscript{170}

The UW workers do not recall being informed of designated smoking areas at MCL, and therefore, were smoking and disposing of cigarettes within AMU1, including flicking them, and saw RT&T employees smoking around, but not within, AMU1.\textsuperscript{171}

11. GOVERNING DIRECTIVES AND PUBLICATIONS

a. Publically Available Directives and Publications Relevant to the Mishap

(1) AFI 51-503, \textit{Aerospace and Ground Accident Investigations}, 14 April 2015
(3) AFI 91-203, \textit{Air Force Consolidated Occupational Safety Instruction}, 15 June 2012

\textbf{NOTICE:} All directives and publications listed above are available digitally on the USAF Departmental Publishing Office website at: http://www.e-publishing.af.mil. Relevant portions of AFI 91-202 that were in effect prior to 24 June 2015 are found at Tab BB-11 to BB-23. The relevant portions of the current AFI 91-202, that were in effect on 5 July 2017, are found at Tab BB-24 to BB-49. The current version of AFI 91-203 contains updates implemented on 24 July 2017. Tab BB-50 to BB-59 contain the relevant portions of AFI 91-203 that were in effect on 5 July 2017.

b. Other Directives and Publications Relevant to the Mishap

(1) 96 TW Safety Guide for Contractors, 1 November 2016 (Tab BB-255 to BB-263)

c. Known or Suspected Deviations from Directives or Publications

(1) AFI 91-203 – Pre-Work Fire Safety Inspection: On 19 June 2017, DFC1 issued a welding permit to UWF for Universal to perform work at AMU1 permitting the cutting and grinding of an “old steel beam,” which also required combustibles to be removed prior to starting

\textsuperscript{168} Tab V-28.10.
\textsuperscript{169} Tab V-19.10 to V-19.11.
\textsuperscript{170} Tab V-19.16 to V-19.17.
\textsuperscript{171} Tabs R-146, V-9.10 to V-9.12, V-33.15, and V-41.6.
work.\textsuperscript{172} Fire watch procedures are also required when welding activities are within 35 feet of combustible materials.\textsuperscript{173}

The R-30 refrigerant is combustible and the refrigerant coils were not drained prior to work starting at AMU1.\textsuperscript{174} Although Universal uses a fire watch during welding operations, the permit did not require a fire watch even though the welding occurred within 35 feet of the refrigerant.\textsuperscript{175}

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25 April 2018
TRAVIS C. HARSHA, Colonel, USAF
President, Ground Accident Investigation Board

\textsuperscript{172} Tabs O-20 and AA-49.
\textsuperscript{173} Tab BB-56. AFI 91-203 at paragraph 27.5.1.8.3.
\textsuperscript{174} Tabs O-46, R-5, and R-87 to R-88. Prior to the issuance of the permit, UWF informed DFC1 that all AMU1 coils were empty and neither UWF or the UWs knew otherwise until about a week and a half after starting work at AMU1. Tabs R-41, R-54, R-68 to R-69, R-116, R-122, R-143 to R-144, V-6.3, V-7.3, V-7.5 to V-7.7, V-19.9 to V-19.11, and V-41.2. to V-41.3. EAFB Fire Prevention usually holds pre-work meetings for projects using a heat source to outline the procedures for the work and address questions but there was no such meeting for the work at AMU1 and DFC1 did not view the support I-beams to be cut. Tab V-2.1, V-7.5, and V-24.1.
\textsuperscript{175} See Figure 8. Tabs O-20 and AA-49.
## INDEX OF TABS

<table>
<thead>
<tr>
<th>Tab Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution Memorandum and Safety Investigator Information</td>
<td>A</td>
</tr>
<tr>
<td>Not Used</td>
<td>B</td>
</tr>
<tr>
<td>Not Used</td>
<td>C</td>
</tr>
<tr>
<td>Maintenance Reports, Records, and Data</td>
<td>D</td>
</tr>
<tr>
<td>Not Used</td>
<td>E</td>
</tr>
<tr>
<td>Weather and Environmental Records And Data</td>
<td>F</td>
</tr>
<tr>
<td>Personnel Records</td>
<td>G</td>
</tr>
<tr>
<td>Not Used</td>
<td>H</td>
</tr>
<tr>
<td>Not Used</td>
<td>I</td>
</tr>
<tr>
<td>Not Used</td>
<td>J</td>
</tr>
<tr>
<td>Not Used</td>
<td>K</td>
</tr>
<tr>
<td>Not Used</td>
<td>L</td>
</tr>
<tr>
<td>Not Used</td>
<td>M</td>
</tr>
<tr>
<td>Transcripts Of Voice Communications</td>
<td>N</td>
</tr>
<tr>
<td>Any Additional Substantiating Data and Reports</td>
<td>O</td>
</tr>
<tr>
<td>Damage and Injury Summaries</td>
<td>P</td>
</tr>
<tr>
<td>Legal Board Transfer Documents</td>
<td>Q</td>
</tr>
<tr>
<td>Releasable Witness Testimony</td>
<td>R</td>
</tr>
<tr>
<td>Releasable Photographs, Videos, and Diagrams</td>
<td>S</td>
</tr>
<tr>
<td>Personnel Records Not Included In Tab G</td>
<td>T</td>
</tr>
<tr>
<td>Maintenance Records and Data Not Included In Tab D</td>
<td>U</td>
</tr>
<tr>
<td>Witness Testimony and Statements</td>
<td>V</td>
</tr>
<tr>
<td>Weather And Environment Records and Data Not Included In Tab F</td>
<td>W</td>
</tr>
</tbody>
</table>