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## **Inclement Weather Crater Repair Tool Kit**

Haley P. Bell and Jeb S. Tingle

November 2017



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# **Inclement Weather Crater Repair Tool Kit**

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## Abstract

During the period October 2015 through May 2016, the U.S. Army Engineer Research and Development Center (ERDC) in Vicksburg, MS, worked to develop a prototype tool kit comprised of equipment and materials needed to repair concrete and asphalt craters on airfield pavements during times of inclement weather. The tool kit is used to supplement an existing crater repair tool kit developed for fair weather scenarios. The items selected for inclusion in the kit were based on previous research and evaluation of crater repair methods and during specific full-scale inclement weather crater repair experiments. This report presents a summary of the research conducted to help determine the prototype Inclement Weather Crater Repair Tool Kit contents and also presents the specific details of the kit, including inventory and drawings.

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## Preface

The Inclement Weather Crater Repair Tool Kit was developed for the U.S. Air Force Civil Engineer Center (AFCEC). The technical monitor was Dr. Craig Rutland, AFCEC.

The work was performed by the Airfields and Pavements Branch (GMA) of the Engineering Systems and Materials Division (GM), U.S. Army Engineer Research and Development Center, Geotechnical and Structures Laboratory (ERDC-GSL) and Fairlead Precision Integration and Manufacturing in Portsmouth, VA. At the time of publication, Dr. Timothy W. Rushing was Chief, CEERD-GMA; Dr. G. William McMahon was Chief, CEERD-GM; and Mr. R. Nicholas Boone, CEERD-GVT, was the Technical Director for Force Projection and Maneuver Support. The Acting Deputy Director of ERDC-GSL was Mr. Charles W. Ertle, and the Director was Mr. Bartley P. Durst.

COL Bryan S. Green was the Commander of ERDC, and Dr. David W. Pittman was the Director.

## Unit Conversion Factors

Multiply	By	To Obtain
degrees Fahrenheit	$(F-32)/1.8$	degrees Celsius
feet	0.3048	meters
gallons (US liquid)	3.785412 E-03	cubic meters
inches	0.0254	meters
pounds (force)	4.448222	newtons
pounds (force) per square inch	6.894757	kilopascals



# 1 Introduction

## 1.1 Background

The U.S. Air Force's Rapid Airfield Damage Repair (RADR) Program developed technologies to return bomb-damaged runways and taxiways to full operational sortie production within 3 (objective) to 6.5 hr (threshold) after an attack. The objective is the desired goal, and the threshold is the maximum time allotted for crater repair. Damaged pavements must be repaired using fast methods and durable materials to reduce the total time that the pavement is removed from service, as well as to reduce the need to conduct subsequent repairs to maintain an operable pavement surface, particularly during wartime scenarios. In addition to military wartime repair scenarios, damaged military and civilian airfields must also be repaired quickly; and these repairs must be capable of withstanding aircraft traffic at full operational levels to ensure long-lasting repairs.

Several airfield pavement repair kits, developed for various purposes, have been procured and deployed in recent years to provide all the supplies and equipment needed to perform pavement repairs in austere environments. The tool kits include the Sustainment Pavement Repair (SuPR) Kit, the Spall Repair Kit, the Expedient Crater Repair Kit, the Airfield Damage Repair (ADR) Tool Trailer, and Rubber Removal equipment. The equipment, methods, and materials for each scenario are standardized and can be used by all military services.

The technologies involved in the crater repair process of airfield pavements include compact track loaders (CTLs) with wheel saw, broom, and bucket attachments; wheeled excavators; front-end loaders; utility vehicles; extendable boom forklifts; simplified volumetric mixers; dump trucks; water trucks; flatbed trailers; rapid-setting cementitious materials; and a variety of concrete finishing tools.

These technologies and processes have been tested in cold, hot and dry, and wet weather. The ADR base recovery process may encounter situations in which crater repairs need to be conducted during periods of inclement weather (e.g., rainy or cold weather). These situations require additional materials and equipment to successfully complete the repairs. Various materials, equipment, and processes were evaluated in inclement

weather conditions (Bell et al. 2013 and Edwards et al. 2013). Specific materials and equipment have been down-selected since the evaluations. An ADR tool trailer containing the necessary small tools and equipment for the ADR base recovery process was developed. However, a prepackaged supplemental tool kit was needed to ensure that the materials and equipment specific to inclement weather are readily available to the warfighters when necessary. The supplemental kit is the Inclement Weather Crater Repair Tool Kit described in this report.

## **1.2 Objective and scope**

The objective of this project was to develop and procure a specialized prototype tool kit that included the materials and equipment necessary to supplement the basic crater repair package for use in inclement weather. The key parts of this research were to develop, procure, and evaluate special tools kits for augmenting the current ADR base recovery repair package. This involved (1) reviewing, evaluating, and specifying the necessary supplemental equipment and materials and (2) fabricating the prototype tool kit.

Chapter 2 summarizes crater repair research tests, Chapter 3 presents the contents of the prototype Inclement Weather Crater Repair Tool Kit, and Chapter 4 notes the conclusions. The items described in this report were included in the prototype kit. The fielded tool kits may have some approved item substitutions that were deemed equivalent to the prototype kit contents.

## 2 Inclement Weather Crater Repair Research

This chapter gives an overview of the bomb-crater repair process and presents a summary of crater repair research conducted in wet weather (Bell et al. 2013, Pullen et al. 2014) and cold weather (Edwards et al. 2013) scenarios. The wet weather repairs were conducted in sustained rainfall of approximately 3/8-in. per hr, and the cold weather repairs were conducted in air temperatures between 33 to 35°F.

### 2.1 Crater repair process

The crater repair process consists of eight key tasks conducted by teams of airmen using specific equipment and materials: (1) initial debris removal, (2) marking, (3) hauling, (4) saw cutting, (5) excavating, (6) backfilling, (7) capping, and (8) final debris removal. Figure 1 shows a 9-ft by 9-ft rapid-setting concrete crater repair before cure. The number of teams needed for repairing craters is dependent on the number of necessary repairs. Each task is completed using a set number of team members with the necessary equipment and materials. Each crater repair team is led by a Crater team leader who is responsible for accomplishing the repair objective, directing the repair personnel, and ensuring the quality of each repair.

Figure 1. Rapid-setting concrete crater repair.



The first task for repairing craters is debris removal. The debris removal team begins the crater repair process by clearing the path from the staging area to the minimum operating strip (MOS) and then removing debris from each crater to be repaired in sequence.

The second task for crater repairs is hauling material. The haul team is responsible for mobilizing the repair materials and supplementary equipment from the staging area to the repair site. The primary repair materials requiring dedicated haul team assets include the super sacks of flowable fill and rapid-setting concrete, which are hauled from the storage site to the repair site (Figure 2). The repair materials and supplementary equipment are loaded onto a tractor-trailer.

Figure 2. Trailer hauling super sacks of cementitious material.



The marking team uses line-of-sight stanchions to help identify the crater upheaval. Stanchions consist of two sighting stands placed outside of the upheaved area and a target rod that is systematically moved within the upheaved area to determine where the upheaved pavement begins and ends. Figure 3 shows the stanchions being used during a wet weather crater repair test. Once the upheaval is identified, the marking team paints lines outlining the crater repair area as a guide for the saw-cutting team.

Figure 3. Crater profile measuring using stanchions.



Saw cutting begins once the marking team completes its duties. Saw cutting can be the slowest task in the crater repair process. The current saw-cutting protocol calls for two wheel saws attached to CTLs to cut the crater upheaval simultaneously, as shown in Figure 4. Each wheel saw cuts two lines per crater. A walk-behind saw can be used in locations where dowel bars are present.

Figure 4. Saw cutting around crater upheaval.



The excavation team is responsible for breaking up the damaged portland cement concrete (PCC) within the cut crater repair area and removing the disturbed subsurface material. An excavator with a hammer attachment is used for breaking any large sections of the existing pavement within the repair area, and a second excavator with a bucket attachment is used for removing the broken pavement and disturbed underlying material.

The backfill team, which utilizes the same personnel as the marking team, is responsible for filling the prepared excavation to the target surfacing depth, using material with sufficient bearing capacity to support heavy aircraft operations. Pre-blended rapid-setting flowable fill is the recommended material for backfilling craters. This material can be placed by using either dry or wet methods.

The dry method consists of emptying super sacks of the flowable fill material into the excavated crater, spreading the material, and then adding a predetermined amount of water on top of the dry material, completing the procedure in 4- to 6-in.-thick lifts. The dry method is conducted more commonly than the wet method due to its simplicity and minimal equipment requirements. Figure 5 shows a super sack of flowable fill being dumped inside the repair.

Figure 5. Placing flowable fill backfill using the dry method.



The wet method is completed by using a simplified volumetric mixer. Procedures for mixing and placing rapid-setting flowable fill using the volumetric mixer include filling the dry material bin with the pre-blended

rapid-setting flowable fill, filling the water tanks of the mixer, applying a release agent to the mixer chute and hand tools, adjusting the machine to the flowable fill setting to ensure the appropriate quantity of mix water, and placing the mixed backfill into the excavated crater as needed. Wet-placed rapid-setting flowable fill is extremely fluid and self-leveling while still able to set within 30 min of placement to allow for placement of the crater cap material. Figure 6 shows the simplified volumetric mixer.

Figure 6. Simplified volumetric mixer.



Concrete capping is the seventh task in the crater repair sequence. The capping team is responsible for placing a level pavement surfacing capable of supporting heavy aircraft operations within the objective time threshold. Rapid Set Concrete Mix<sup>®</sup> or hot-mixed asphalt (HMA) can be used as capping material for crater repairs. The mixing and placement of the capping material is conducted using only the simplified volumetric mixer (Figure 6) for PCC or appropriate HMA batching and placement equipment. Figure 7 shows a repair being capped with Rapid Set Concrete Mix<sup>®</sup> using the simplified volumetric mixer.

The final task in the crater repair sequence consists of final debris clearance. Angle brooms, foreign object debris (FOD) removal equipment, and vacuum trucks are used to remove any debris remaining from the original damage or the repair process. The PCC or HMA crater caps are allowed to cure or cool, respectively, while the final debris removal is conducted.

Figure 7. Crater repair with Rapid Set Concrete Mix® using the volumetric mixer.



The results of many full-scale tests of the crater repair process previously described led to the development of an ADR equipment set and an ADR tool trailer kit to be deployed to various military airfields. The specific equipment, tools, and materials are needed to complete the key crater repair tasks. The generic ADR equipment set for crater repairs consists of

- Graders,
- Dozer,
- Loaders,
- Tractors,
- Trailer (60-ton lowboy),
- Vacuum sweepers,
- Tractor-mounted sweepers,
- Warehouse forklift (6,000 lb),
- Trailer (40 ft) - material,
- Extendable boom forklifts (11,000 lb),
- Extendable boom forklift attachment package,
- Dump trucks,
- Wheeled excavators,
- Excavator attachment package,
- Pneumatic rollers,
- Vibratory rollers,
- Water truck (1,500 gal),
- Compact track loader (CTL),



- CTL attachment package,
- Trailer (40 ft) - attachments,
- Volumetric mixer,
- Water trailer (2,000 gal),
- Asphalt recycler,
- Light carts, and
- Dump truck water skids (1,000 gal).

The ADR Tool Trailer consists of over 150 items -- including tools, materials, and small equipment -- needed to perform small and large crater repairs. The Increment Weather Crater Repair Kit was developed as a supplemental kit to the ADR Tool Trailer to provide additional tools and materials necessary for the repair of craters under wet weather or cold climate conditions.

## **2.2 Cold weather crater repair testing**

Full-scale timed tests on concrete crater repairs conducted in cold weather were performed at Malmstrom Air Force Base in Great Falls, MT, in March 2012 (Edwards et al. 2013). The main objective of this cold weather crater repair test was to learn how sustained cold temperatures of less than 40°F affect equipment operation and repair material performance. Air temperatures during the test were between 33 and 35°F. The wind chill temperatures were between 23 and 27°F.

The crater repair tasks were conducted in the cold weather in the same manner as if they were being repaired in hot, dry weather. However, because of the cold air temperatures, an additive was used for the capping material. Aluminum sulfate was added to the mix water before the placement of the Rapid Set Concrete Mix<sup>®</sup>. Aluminum sulfate is an additive intended to reduce the amount of curing time so that the surface will set. Rapid Set Concrete Mix<sup>®</sup> has a normal set time of 20 to 30 min, depending on the air temperature. However, the set time was anticipated to increase at temperatures below 40°F.

Additional technologies, such as curing blankets and plastic sheeting, were evaluated. The curing blankets were used in the cold weather to help trap some of the exothermic heat while the concrete cured. The plastic sheeting served the same purpose. However, it was determined that the curing blankets and plastic sheeting were not necessary for the concrete curing.

In some instances, it appeared that covering the repairs made the curing process excessively slow.

The debris removal, damage delineation, marking process, upheaval and disturbed material removal, and backfilling processes (dry method) were not affected by the cold weather; all the equipment for the repairs worked well in the low temperatures. However, there was an increased potential for shrinkage cracks in the rapid-setting concrete cap when the air temperature was below 40°F. The shrinkage cracks that formed because of the low temperature did not seem to affect performance. There was concern that the manufacturer had not included the shrinkage-reducing admixture due to an error at the plant.

Two hours after the completed repair of the final crater, each repair was trafficked to 112 passes of simulated F-15E aircraft loads. The 112-pass level is the threshold established for expedient RADR repairs. The single-wheel F-15E load cart was rigged such that the aircraft tire was loaded to approximately 35,235 lb with 325-psi tire pressure, representative of the maximum loading for the F-15E aircraft. Core samples of the rapid-setting concrete caps extracted from the five repairs resulted in an average 28-day compressive strength of 5,800 psi, which was over the requirement of 5,000 psi.

### **2.3 Wet weather crater repair testing**

Wet weather crater repair testing was completed for concrete repairs at the Silver Flag Exercise Site in Tyndall Air Force Base, FL, in June 2012 (Bell et al. 2013). Wet weather crater repair testing was completed for asphalt repairs at the same test site in September 2013 (Pullen et al. 2014). The main objective of the wet weather crater repair tests was to evaluate the materials, equipment, and processes under inclement weather conditions of sustained rainfall. The air temperatures ranged from 77 to 89°F during the concrete tests and 71 to 84°F during the asphalt tests.

Simulated rainfall was made possible by the construction of a sprinkler system mounted on ten 40-ft-high wooden utility poles (Figure 8). The utility poles supported cables with polyvinyl chloride (PVC) pipes mounted with sprinkler heads above the test area. The 75- by 200-ft sprinkler system simulated constant rainfall of 3/8 in. per hr during each test.

Figure 8. Calibrated sprinkler system used for wet weather crater repair tests.



Additional equipment and supplies were required to mitigate the potential for adverse impact of the rainfall during the crater repair process. These items included solid paint crayons for marking pavement, pop-up tents for placing the rapid-setting concrete caps, crater caps for mitigating the entrance of water into the repairs during cure times, barriers for surface runoff, backpack leaf blowers, and tarps for mitigating water into the repairs during HMA cap placement. These items are necessary to ensure quality repairs during wet conditions.

For the concrete crater repair tests, initial debris removal, marking and damage delineation, and backfilling processes were not affected by the wet weather. All equipment performed well. The rapid-setting flowable fill (dry method) and the rapid-setting concrete material met the strength requirements for concrete crater repair despite the wet weather. The typical strength observed for the rapid-setting flowable fill placed by using the dry method under the wet weather conditions was 100 CBR with two out of the six craters showing lesser strength profiles ranging from 40 to 80 CBR. The rapid-setting concrete cap produced average compressive strengths of 6,700 psi, well in excess of the typical 5,000 psi required for airfield pavements.

All rapid-setting concrete repairs were able to sustain the threshold traffic for expedient repairs of 112 passes of the F-15E load cart. No cracking was observed after the initial 112 passes. The crater that showed the greatest potential for FOD after it was repaired sustained 3,500 passes (the

sustainment level of traffic) of the F-15E load cart without any excessive cracking or increased FOD potential.

For the asphalt crater repair tests, the equipment was not significantly affected by the wet weather. Water mitigation and removal techniques adequately maintained dry areas of HMA capping operations. Dump truck and ground stockpile HMA storage methods both maintained a minimum HMA temperature of 280°F for 1.5 hr. Also, initial profile measurements indicated 100% of the HMA repairs met the repair quality criterion of being within  $\pm 0.75$  in. of the existing pavement.

After completion of the six repairs, each asphalt-capped repair was subjected to 112 passes of fully loaded simulated F-15E traffic. Rut depth measurements after trafficking showed that the HMA repairs deformed less than 0.125 in. The repair that showed the greatest potential for failure was trafficked further. After 1,984 passes, traffic was stopped due to reaching 1 in. of permanent surface pavement deformation. Also, the repair presented a tire hazard because the HMA surface had debonded from the flowable fill surface, beginning around pass 500.

### **3 Inclement Weather Crater Repair Tool Kit Contents**

The Inclement Weather Crater Repair Tool Kit prototype was developed following the conclusion of the wet weather and cold weather crater repair tests described in Chapter 2. The results and the lessons learned from the full-scale experiments aided in the selection of the necessary kit contents described in this chapter. The intention of the Inclement Weather Crater Repair Tool Kit is to supplement the ADR Tool Trailer.

The Inclement Weather Crater Repair Tool Kit includes approximately 20 different items plus their respective accessories strategically packed into two quadcon dry freight ISO cargo containers. The generic kit contents, including items from Container 1 and Container 2, are presented in Table 1. The contents include items and equipment needed for asphalt and concrete crater repairs in wet or cold weather. The packaged weights of Container 1 and Container 2 are approximately 3,210 and 5,890 lb, respectively.

The design drawings of the kit are provided in Appendix A. The drawings include detailed information about each container's outfitting and the kit contents, item locations, dimensions, and weights. The drawings also show various views of the containers. The quadcon containers and each individual tool, equipment, basket, bolt, etc. were assigned an item number, as shown in the tables of Appendix A. The item numbers shown in parentheses in the following paragraphs are referencing the item numbers shown in the table located on Sheet 2 in Appendix A.

The corrugated steel quadcons (Item 1) are equipped with double swing doors on both ends of the containers (Figure 9). Each quadcon is approximately 8 ft long, 8 ft high, and 4 ft 9.5 in. wide and weighs approximately 2,500 lb empty. The quadcon containers allow the kits to be deployable with their four-way fork-lift pockets and provide an option to be attached together using the connecting couplers (Figure 10). Four quadcon containers coupled together makes up one standard 20-ft ISO container.

Table 1. Inclement Weather Crater Repair Tool Kit contents.

Description	Quantity	Container
dry-line marker	1	1
30-ft-long custom fire hose	18	2
2.5-in.-diameter dust cap coupler (for fire hose)	18	2
2.5-in-diameter dust plug adapter (for fire hose)	18	2
10-ft-long polyurethane containment dike	36	2
12-in.-diameter No. 10 sieve	4	2
20-ft x 100-ft plastic sheeting	2	2
16-ft x 20-ft 18-oz. vinyl-coated tarp	24	2
5-gal wet/dry vacuum, hose, and accessories	1	1
backpack leaf blower with extensions	3	1
5-gallon plastic buckets with lids	36	1
10-ft x 10-ft heavy duty pop-up tent	10	2
red or orange paint crayons, 12 count	5	1
30-ft-long pipe heater cable	2	1
18-ft-long automatic electric heat cable	2	1
nylon tent anchor bags	44	2
multi-fuel in-line water heater	1	1
3-in. centrifugal water pump - 290 gal/min	1	1
metal suction hose strainer (for water pump)	1	1
20-ft-long suction hose (for water pump)	1	1
50-ft-long discharge hose (for water pump)	1	1
aluminum scoop	1	1

Figure 9. Corrugated steel quadcons.



Figure 10. Quadcon connecting couplers.



Inside the kit, wire baskets (Items 30 and 31) and a 50-gal plastic tote (Item 37) are used to hold smaller, loose items. Figure 11 shows one of the three wire baskets, and Figure 12 shows the plastic tote used to hold the smaller miscellaneous items in the prototype kit.

Figure 11. Collapsible wire basket.



Figure 12. 50-gal plastic tote.



The larger, heavier items are placed on the container floor or mounted on the container walls and are secured using various-sized ratchet straps (Items 24 and 41). The larger tie-down cargo aircraft ratchet straps are about 1.75 in. wide and 20 ft long with steel connectors and are made of nylon webbing. The smaller polyester ratchet straps are 1 in. wide by 2 ft long and include coated S-hooks. Figure 13 shows the two ratchet-strap sizes used in the kit.

Figure 13. Ratchet straps.



The 1.75-in.-wide by 20-ft-long ratchet straps were used to secure the items on the floor, in the wire baskets, and on the walls. The 1-in.-wide by 2-ft-long ratchet straps were used to secure the hoses of the backpack leaf blowers to the wall. The ratchet straps are secured to the floor or walls of the container using welded stud (Item 23), hexagonal nut (Item 25), washer (Item 26), and surface mount rope ring (Items 29 and 34) systems (12,000- or 1,000-lb working limit), as shown in Figure 14.



Figure 14. 12,000-lb (left) and 1,000-lb (right) surface mount rope rings.



Metal placards were secured to the inside of the container doors, displaying the contents of each container. Metal placards were also installed on the outside of each wire basket and the plastic tote, identifying their respective contents. Figure 15 shows a label attached to one of the wire baskets.

Figure 15. Metal label attached to wire basket.



A few of the items in the kit are redundant, particularly the items acting as a water barrier surrounding the perimeter of the open repair to mitigate surface water runoff into the open repair. These redundancy items include the [1] dry-line marker (Item 2), which inherently includes the small shovel (Item 49), 5-gal buckets (Item 12) and bucket lids (Item 13), and the sieves (Item 7); [2] the fire hoses (Item 3), which inherently include the 2.5-in. dust caps (Item 4) and dust plugs (Item 5); and [3] the containment dikes (Item 6). Figure 16, Figure 17, and Figure 18 show each of these items,

respectively. Only one of these technologies is needed to perform as a water barrier around the open repairs. Once users analyze the prototype kit, the barrier items will be down-selected.

Figure 16. Dry-line marker, No. 10 sieve, 5-gal bucket with lid, and scoop.



The empty 5-gal buckets and lids are for collecting sand in theater to use with the dry-line marker and for other needs, such as bailing water out of the crater repair areas or collecting the initial discharge from the volumetric mixer. The collected sand is sieved by hand directly into the buckets by using the No. 10 sieves. This eliminates large aggregates or trash from clogging the dry-line marker when it is used to form a waterproof barrier around the perimeter of the open crater repair area. The small hand shovel/scoop is used to scoop the sand out of the buckets and into the dry-line marker.

Figure 17. Fire hose with dust cap and dust plug.



Figure 18. Polyurethane containment dike.



The paint crayons (Item 15) are used for marking the area for the saws to cut around the upheaval. Paint crayons (Figure 19) are used in place of marking spray paint during rainy weather because the paint crayons are waterproof. Red paint crayons are specified for the kit; however, orange paint crayons are another color option, as they are just as visible during rainy weather.

Figure 19. Red paint crayons.



The 10-ft by 10-ft pop-up tents (Item 14) are made of a heavy-duty industrial-grade 6061-T6 anodized aluminum frame with a vinyl cover. The tents are used to protect the open repair area and the discharge chute of the volumetric mixer during the placement of the rapid-setting concrete caps. The tent anchor bags (Item 18), when filled with sand or aggregate, are used to weigh down the tents during windy conditions. Figure 20 shows the pop-up tent, and Figure 21 shows the tent anchor bags.

Figure 20. Heavy-duty pop-up tent.



Figure 21. Nylon tent anchor bags.



The water trash pump (Item 20), suction hose (Item 21), and discharge hose (Item 22) are used for pumping standing water out of the open repair area. The water pump and suction hose are secured on cantilever mounting arms (Item 38) installed on the wall of one of the containers. The suction hose strainer (Item 48) helps to ensure that large items, such as pieces of concrete or aggregate, are filtered to protect the equipment. Figure 22 shows the water pump with the hoses and the strainer installed.

Figure 23 shows one of the three Husqvarna backpack leaf blowers (Item 11) included in the prototype kit. The backpack leaf blower is used to remove standing water from the backfill surface immediately prior to capping the repairs. The wet/dry Shop-Vac vacuum (Item 10) shown in Figure 24 can also be used for extracting water from the repairs. Figure 24 also shows the accessories that come with the vacuum. The backpack leaf blowers are hung by custom short hangers (Item 39) on the wall of one of the containers, and the vacuum is hung by a custom long hanger (Item 33) on the wall of one of the containers.

Figure 22. Water trash pump, discharge hose, suction hose, and strainer.



Figure 23. Backpack leaf blower with extendable arm accessories.



Figure 24. Wet/dry Shop-Vac vacuum and accessories.



Coated vinyl tarps (Item 9), such as the one shown in Figure 25, are used to protect the backfill surface from rainfall after placement while waiting for capping to begin. They are also used to cover and protect the asphalt caps while compaction is taking place. The 16- by 20-ft tarps will not melt when placed over the hot asphalt surface during compaction and curing.

Figure 25. Vinyl tarps.



Black 6-mil polyethylene sheeting (Item 8) in 20- by 100-ft rolls is included in the kit because it may be necessary for placement over the freshly capped repairs to help trap some of the heat needed for proper curing of the rapid-setting concrete during low temperatures. Figure 26 shows one of the 20- by 100-ft rolls of the plastic sheeting.

Figure 26. Polyethylene sheeting.



The 18- and 30-ft-long electric heating cables (Items 17 and 16, respectively) are used to cover the water lines of the simplified volumetric mixer during capping when the air temperatures are at or below freezing. They may also be used to protect the water pump on the mixer. Figure 27 shows the front and back package of the 30-ft-long water pipe heat cable.

Figure 27. 30-ft-long electric water pipe heat cable.





The in-line water heater (Item 19) is another item used for crater repair during cold weather. The heater (Figure 28) rapidly heats water from a local source as it is loaded into the mix tanks of the simplified volumetric mixer. A 3-ft-long by 2.5-ft-wide metal ramp (Item 27) is included and mounted on the inside door of one of the containers for loading and unloading the 330-lb inline water heater into and out of the container. The ramp is mounted using a custom manufactured ramp hangar (Item 28). Figure 29 shows the ramp in use. A 4-in.-long and 0.75-in.-wide aluminum stop (Item 44) is installed on the floor and in front of the heater to keep the heater from shifting inside the container during transit.

Each container is equipped with safety signs, as shown in Figure 30. The signs are included to remind the users to exercise caution when opening or working around the containers and to protect the users from harm due to the potential issues with residual fuel used in some of the tools included in the kit.

Figure 28. In-line water heater.



Figure 29. Unloading in-line water heater using metal ramp.



Figure 30. Warning and danger signs adhered to container doors.



## 4 Conclusions

This report presents a summary of two full-scale crater repair experiments: (1) crater repair tests conducted in wet weather and (2) crater repair tests conducted in cold weather. The results of the full-scale tests led to the development of the prototype Inclement Weather Crater Repair Tool Kit, which was developed to supplement the ADR Tool Trailer during times of cold or wet weather. This report also includes the details of the tools, supplies, and equipment that were selected and packaged in the prototype Inclement Weather Crater Repair Tool Kit.

Critical items needed to mitigate the potential for adverse impact of rainfall during the crater repair process include

- Wet/dry-line marker,
- 30-ft-long fire hose with dust caps and dust plugs,
- 10-ft-long water containment dikes,
- No. 10 sieves,
- 16-ft by 20-ft coated vinyl tarps,
- Wet/dry vacuum,
- Backpack leaf blowers,
- 5-gal buckets with lids,
- 10-ft by 10-ft pop-up tents,
- Paint crayons,
- Tent anchor bags,
- Water trash pump with suction and discharge hoses and strainer, and
- Hand scoop.

Critical items needed for repairing craters in cold weather include

- 20-ft by 100-ft plastic sheeting,
- 30-ft-long electric pipe heat cable,
- 18-ft-long electric pipe heat cable, and
- In-line water heater.

## References

- Bell, H. P., L. Edwards, W. D. Carruth, J. S. Tingle, and J. R. Griffin. 2013. *Wet weather crater repair testing at Silver Flag Exercise Site, Tyndall Air Force Base, Florida*. ERDC/GSL TR-13-42. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
- Edwards, L., H. P. Bell, W. D. Carruth, J. R. Griffin, and J. S. Tingle. 2013. *Cold weather crater repair testing at Malmstrom Air Force Base, Montana*. ERDC/GSL TR-13-32. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
- Pullen, A., C. Jackson, and B. Cotter. 2014. *2013 wet weather HMA crater repair technology demonstration*. AFCEC-CX-TY-TR-2014-0026. Panama City, FL: Applied Research Associates.

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## **Appendix: Inclement Weather ADR Crater Repair Prototype Tool Kit Design Drawings**

6	5	4	3	2	1
D	D	C	B	A	A
<p><b>NOTES:</b></p> <p>1. INTERPRET WELDING AND NON-DESTRUCTIVE TESTING SYMBOLS IN ACCORDANCE WITH (IAW) AMERICAN WELDING SOCIETY (AWS) A2.4-1988. ALL WELDING AND JOINT DESIGN SHALL BE IAW APPROVED PROCEDURE AS IDENTIFIED IN THE WELD CALLOUT.</p> <p>2. INTERPRET SURFACE TEXTURE SYMBOLS IAW AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) Y14.36M-1996. MACHINED SURFACES SHALL BE 250 RA PER ASME B46.1-2009.</p> <p>3. REMOVE BURRS AND SHARP EDGES.</p> <p>4. UNLESS OTHERWISE SPECIFIED ALL FASTENERS TO BE HAND TIGHT, BASED ON NORMAL MECHANICS PRACTICES USING WRENCH OR OTHER DEVICE WITHOUT MEASURING TORQUE.</p> <p>5. THE TOTAL ESTIMATED WEIGHT (CALCULATED WEIGHT PLUS 10% OF THE ASSEMBLIES IS AS FOLLOWS: CONTAINER 1.....3,715 LB CONTAINER 2.....8,740 LB</p> <p>6. FIRE HOSE, CUSTOM (ITEM 3) IS MADE OF THE FOLLOWING FLORIDA HOSE AND RUBBER PART NUMBERS: 4703-2501 MILL HOSE, E260A MALE CAMLOCK, C280A FEMALE CAMLOCK, AND FS14 DOUBLE BAND. AFTER THESE PARTS ARE ASSEMBLED THE ENTIRE ASSEMBLY IS SHEATHED WITH PART NUMBER 4502-3000 DISCHARGE HOSE AND SECURED WITH FS14 DOUBLE BAND.</p>	<p><b>NOTES:</b></p> <p>11. STENCIL 1 INCH (MINIMUM) HIGH BLOCK CHARACTERS ON THE OUTSIDE OF THE LEFT DOOR OF EACH CONTAINER AS FOLLOWS: *WEATHER CONT. 1 OF 2" *WEATHER CONT. 2 OF 2" RESPECTIVELY AS IDENTIFIED IN THE BODY OF THE PLAN. MARKING SHALL BE IN A CONSPICUOUS LOCATION AT OR ABOVE EYE LEVEL AND PERFORMED WITH BLACK ENAMEL PAINT (MIL-PRF-24635; FED-STD-595, COLOR CHIP 27041 OR EQUIVALENT). CARE SHALL BE TAKEN THAT MARKING DOES NOT INTERFERE WITH ANY IDENTIFYING MARKING OR LABELS PRESENT ON THE EXTERIOR OF THE CONTAINER.</p> <p>12. WARNING LABEL (ITEM 43) SHALL BE VINYL STICKY BACK. THE FIELD OF THE LABEL SHALL BE SCHOOL BUS YELLOW (FED-STD-595, COLOR CHIP 13419), FONT STYLE ARIAL SIZED AND SPACED PER SHEET 13, FONT COLOR IS BLACK (FED-STD-595, CHIP COLOR 27041).</p> <p>13. LABEL KIT SHALL BE PRINTED ANODIZED ALUMINUM. ALUMINUM SHALL BE .02 PRINTING SHALL BE BLACK LETTERS ON A CLEAR FIELD. FONT STYLE SHALL BE ARIAL AND A MINIMUM OF 10 POINT AND MAXIMUM OF 12 POINT IN HEIGHT. SIZE OF LABEL ARE AT MANUFACTURERS DISCRETION AND DICTATED BY CONTENT OF THE LABEL AS SHOWN ON SHEET 16. HOLES SHALL BE PLACED IN EACH CORNER OF THE LABEL BY THE MANUFACTURER TO FACILITATE INSTALLATION. LABEL SHALL BE AFFIXED TO THE INSIDE OF THE RESPECTIVE CONTAINERS DOOR AT APPROXIMATELY EYE LEVEL ON EACH END OF THE CONTAINER. THE METHOD OF ATTACHMENT AT FABRICATING FACILITY DISCRETION AND SHOULD BE CONSIDERED PERMANENT.</p>	<p><b>NOTES:</b></p> <p>16. LABELS SHALL BE PRINTED ANODIZED ALUMINUM. ALUMINUM SHALL BE .02 PRINTING SHALL BE BLACK LETTERS ON A CLEAR FIELD. FONT STYLE SHALL BE ARIAL AND A MINIMUM OF 10 POINT AND MAXIMUM OF 12 POINT IN HEIGHT. SIZE OF LABEL ARE AT MANUFACTURERS DISCRETION AND DICTATED BY CONTENT OF THE LABEL AS SHOWN ON SHEET 16. HOLES SHALL BE PLACED IN EACH CORNER OF THE LABEL BY THE MANUFACTURER TO FACILITATE INSTALLATION. LABEL SHALL BE AFFIXED TO THE INSIDE OF THE RESPECTIVE CONTAINERS DOOR AT APPROXIMATELY EYE LEVEL ON EACH END OF THE CONTAINER. THE METHOD OF ATTACHMENT AT FABRICATING FACILITY DISCRETION AND SHOULD BE CONSIDERED PERMANENT.</p>	<p><b>NOTES:</b></p> <p>14. STRUCTURAL WELD JOINT DESIGN SHALL BE IAW NOTE 1. ALL WELDING AND INSPECTION SHALL BE IN ACCORDANCE WITH 14A: 14A. NAVAL SEA SYSTEMS COMMAND (NAVSEA) TECHNICAL PUBLICATION S9074-AR-GIB-010/278 CLASS M-2 CATEGORY C (QUALIFICATION AND TESTING IAW SECTION 4.2.1.1 NOT REQUIRED). ALL WELDS SHALL BE NDT VISUALLY INSPECTED TO 1X MAGNIFICATION ON THE COMPLETED SURFACE IAW T9074-AS-GIB-010/271. ACCEPTANCE CRITERIA SHALL BE IAW MIL-STD-2035.</p> <p>15. ITEMS 3, 4, AND 5 HAVE BEEN ASSEMBLED AND STORED IN CONTAINER 2 BASKET 2.</p>	<p><b>NOTES:</b></p> <p>16. LABELS SHALL BE PRINTED ANODIZED ALUMINUM. ALUMINUM SHALL BE .02 PRINTING SHALL BE BLACK LETTERS ON A CLEAR FIELD. FONT STYLE SHALL BE ARIAL AND A MINIMUM OF 10 POINT AND MAXIMUM OF 12 POINT IN HEIGHT. SIZE OF LABEL ARE AT MANUFACTURERS DISCRETION AND DICTATED BY CONTENT OF THE LABEL AS SHOWN ON SHEET 16. HOLES SHALL BE PLACED IN EACH CORNER OF THE LABEL BY THE MANUFACTURER TO FACILITATE INSTALLATION.</p>	<p><b>NOTES:</b></p> <p>16. LABELS SHALL BE PRINTED ANODIZED ALUMINUM. ALUMINUM SHALL BE .02 PRINTING SHALL BE BLACK LETTERS ON A CLEAR FIELD. FONT STYLE SHALL BE ARIAL AND A MINIMUM OF 10 POINT AND MAXIMUM OF 12 POINT IN HEIGHT. SIZE OF LABEL ARE AT MANUFACTURERS DISCRETION AND DICTATED BY CONTENT OF THE LABEL AS SHOWN ON SHEET 16. HOLES SHALL BE PLACED IN EACH CORNER OF THE LABEL BY THE MANUFACTURER TO FACILITATE INSTALLATION.</p>
B	B	A	A	A	A
<p>7. LABELS SHALL BE AFFIXED TO THE APPROPRIATE BASKET AS CALLED OUT IN THE BODY OF THE PLAN. METHOD OF ATTACHMENT SHALL BE CONSIDERED PERMANENT AND AT SHOPS DISCRETION. NO MODIFICATION OF STRUCTURAL ELEMENTS OF THE BASKET IS PERMITTED.</p> <p>8. ALL STUD WELDING SHALL BE IAW AWS D1.1. STUDS SHALL BE NON-DESTRUCTIVE TESTED (NDT) IAW AWS D1.7 SECTION 7. METHOD OF TEST SHALL BE AT THE FABRICATING FACILITIES DISCRETION. ACCEPTANCE CRITERIA SHALL BE IAW THE CHOSEN TEST METHOD AND AWS D1.1 SECTION 7.</p> <p>9. NO SMOKING LABEL (ITEM 42) SHALL BE AFFIXED TO THE INSIDE OF THE RIGHT HAND DOOR OF CONTAINER 1 ON EACH END. THE LABEL SHALL BE AS HIGH AS POSSIBLE ON THE DOOR STRUCTURE AND AFFIXED PER MANUFACTURERS INSTRUCTION.</p>	<p>10. WARNING LABEL (ITEM 43) SHALL BE AFFIXED TO THE OUTSIDE OF THE LEFT DOOR OF CONTAINER 1 ON EACH END. THE LABEL SHALL BE AS HIGH AS POSSIBLE ON THE DOOR STRUCTURE AND AFFIXED PER MANUFACTURERS INSTRUCTION.</p>	<p>10. WARNING LABEL (ITEM 43) SHALL BE AFFIXED TO THE OUTSIDE OF THE LEFT DOOR OF CONTAINER 1 ON EACH END. THE LABEL SHALL BE AS HIGH AS POSSIBLE ON THE DOOR STRUCTURE AND AFFIXED PER MANUFACTURERS INSTRUCTION.</p>	<p>10. WARNING LABEL (ITEM 43) SHALL BE AFFIXED TO THE OUTSIDE OF THE LEFT DOOR OF CONTAINER 1 ON EACH END. THE LABEL SHALL BE AS HIGH AS POSSIBLE ON THE DOOR STRUCTURE AND AFFIXED PER MANUFACTURERS INSTRUCTION.</p>	<p>10. WARNING LABEL (ITEM 43) SHALL BE AFFIXED TO THE OUTSIDE OF THE LEFT DOOR OF CONTAINER 1 ON EACH END. THE LABEL SHALL BE AS HIGH AS POSSIBLE ON THE DOOR STRUCTURE AND AFFIXED PER MANUFACTURERS INSTRUCTION.</p>	<p>10. WARNING LABEL (ITEM 43) SHALL BE AFFIXED TO THE OUTSIDE OF THE LEFT DOOR OF CONTAINER 1 ON EACH END. THE LABEL SHALL BE AS HIGH AS POSSIBLE ON THE DOOR STRUCTURE AND AFFIXED PER MANUFACTURERS INSTRUCTION.</p>
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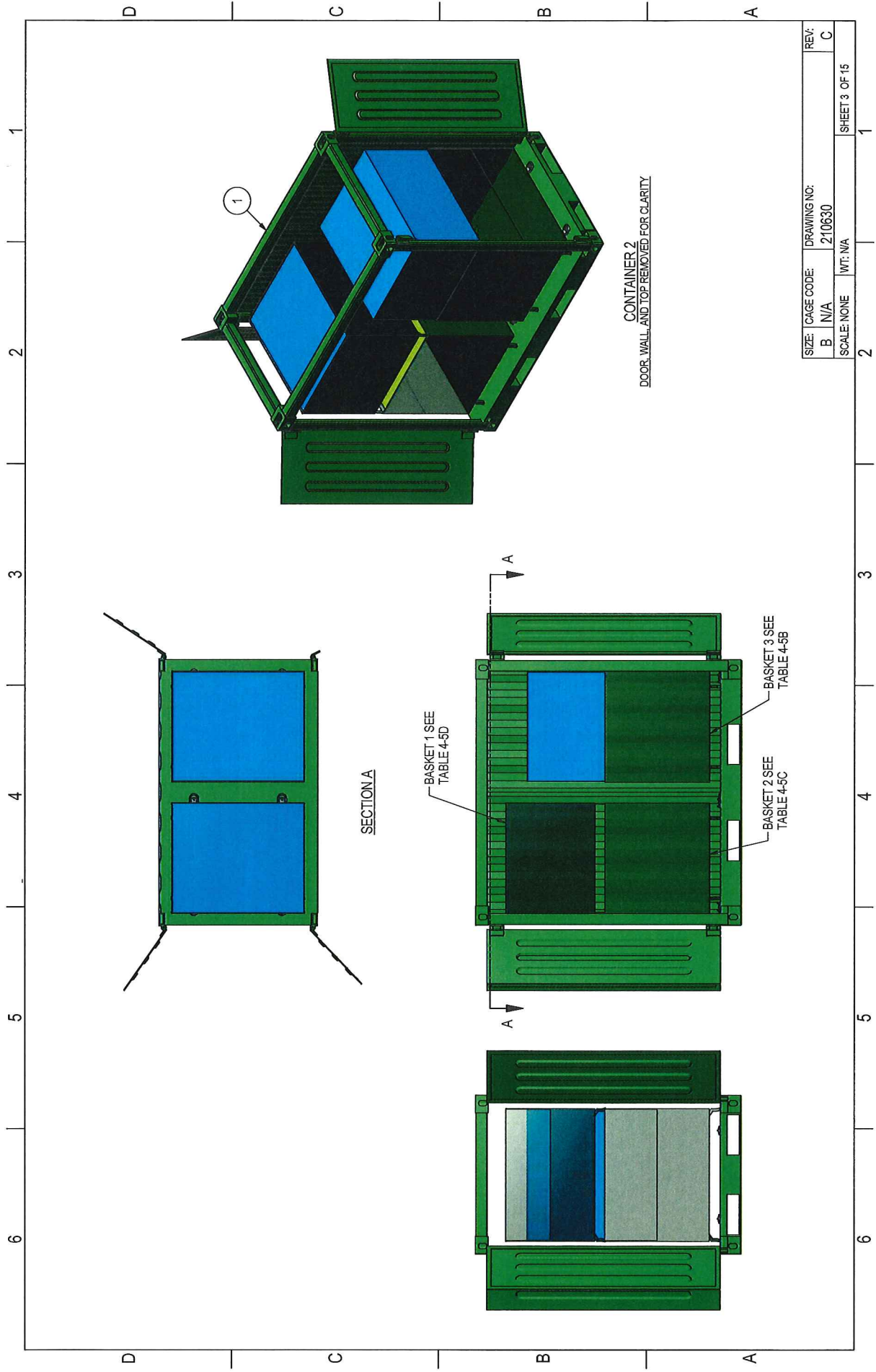
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	PREPARED: J.E.C	DATE: 10/26/2015
TOLERANCES	CHECKED: N/A	DATE: 1/29/2016
ANGULAR ±.5°	ENGINEER: J.E.C	DATE: 1/29/2016
1 PLACE .0 ± .015	APPROVED: J.E.C	DATE: 3/23/2016
2 PLACE .00 ± .010		
3 PLACE .000 ± .005		
4 PLACE .0000 ± .0003		
DRAWING SHALL BE INTERPRETED IAW STANDARDS SPECIFIED BY ASME Y14.100-2013	THIRD ANGLE PROJECTION	

TITLE: INCREMENT WEATHER KIT ARRANGEMENT

SIZE: B	CAGE CODE: N/A	DRAWING NO: 210630	REV: C
SCALE: NONE	WT: N/A	SHEET 1 OF 15	

LIST OF MATERIAL REQUIRED FOR (1) ASSEMBLY

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL	MAT. SPEC	NSN NO	WEIGHT (POUNDS)	NOTES
1	BK06SGD/CV6003	2	QUADCON	VARIOUS	COML	8150-01-533-8677	2476	CMCT
2	P-24-100	1	LINE MARKER	VARIOUS	COML	N/A	58	BLAZER ATHLETIC EQUIPMENT
3	210632	18	FIRE HOSE, CUSTOM, 30 FT LG	VARIOUS	COML	N/A	26	FLORIDA HOSE AND RUBBER, SEE NOTE 6 AND 15
4	DC250A	18	2-1/2" DUST CAP	VARIOUS	COML	N/A	0.94	FLORIDA HOSE AND RUBBER, SEE NOTE 15
5	DP250A	18	2-1/2" DUST PLUG	VARIOUS	COML	N/A	0.94	FLORIDA HOSE AND RUBBER, SEE NOTE 15
6	2-052	36	CONTAINMENT DIKE, 10 FT LG	VARIOUS	COML	7930-01-436-8320	13	ULTRA-SPALL BERM
7	H-3912FS10	4	NO. 10 SIEVE	VARIOUS	COML	N/A	4	HUMBOLDT
8	CP0620B	2	PLASTIC SHEETING, 20 FT X 100 FT	VARIOUS	COML	8135-00-579-6487	29	AIRGAS
9	B461657	24	TARPAULIN	VARIOUS	COML	8340-01-487-5610	45	GLOBAL INDUSTRIAL
10	394-20-00	1	VACUUM	VARIOUS	COML	N/A	16	SHOP-VAC
11	3509T	3	BACKPACK BLOWER	VARIOUS	COML	3750-01-480-0543	22.5	HUSQVARNA
12	T9A23779WH	36	5 GALLON BUCKET	VARIOUS	COML	7240-01-094-4305	2.1	GSA GLOBAL SUPPLY
13	T9A237798WH	36	BUCKET LID	VARIOUS	COML	7240-01-094-4305	1	GSA GLOBAL SUPPLY
14	AF10X10	10	POP UP TENT	VARIOUS	COML	N/A	90	PROMOTIONAL DESIGN GROUP
15	S-19600R	5	PAINT CRAYON, RED, 12 CT	VARIOUS	COML	N/A	1.1	MARKAL
16	HC30	2	PIPE HEATER CABLE, 30 FT LG	VARIOUS	COML	N/A	1.6	FROST KING
17	H018	2	AUTOMATIC HEAT CABLE, ELECTRIC, 18 FT LG	VARIOUS	COML	N/A	1.1	FROST KING
18	JN4W/B400	44	TENT ANCHOR BAGS	VARIOUS	COML	N/A	2.1	KING CANOPY
19	FSI HEAT 200 A	1	INLINE WATER HEATER	VARIOUS	COML	N/A	330	FSI NORTH AMERICA
20	WB30X73	1	WATER PUMP	VARIOUS	COML	N/A	57	HONDA
21	HP03205	1	SUCTION HOSE, 20 FT LG	VARIOUS	COML	N/A	24	MAX TOOL
22	HP03500	1	DISCHARGE HOSE, 50 FT LG	VARIOUS	COML	N/A	18	MAX TOOL
23	101-0174-178	120	STUD, WELDED 3/8-16UNC-2A, 1 LG	STEEL	COML	5307-01-293-1818	0.1	NELSON STUD WELDING
24	FE12687C240	30	TIE DOWN, CARGO, AIRCRAFT	VARIOUS	COML	1670-00-725-1437	3.9	KINEYNE
25	91831A127	120	NUT, HEX, 3/8-16UNC-2B	CRES	COML	N/A	0.01	MCMASTER CARR
26	92141A031	184	WASHER, FLAT, 3/8 NCH, .875 OD	CRES	COML	N/A	0.008	MCMASTER CARR
27	2187133	1	RAMP, 36" WIDE X 18" LONG	ALUMINUM	COML	N/A	16	MCMASTER CARR
28	210636	2	RAMP HANGER, M/F PLATE 3/16 THK	CRES	ASTM-A240	N/A	0.4	FAIRLEAD PRECISION, SEE SH 12
29	02010	26	SURFACE MOUNT ROPE RING, 1000 LB WORKING LIMIT	STEEL	COML	N/A	0.4	TRAILER PARTS SUPERSTORE
30	5066132	1	WIRE BASKET (48 X 40 X 36)	STEEL	COML	N/A	140	MCMASTER CARR
31	5066172	2	WIRE BASKET (48 X 40 X 42)	STEEL	COML	N/A	166	MCMASTER CARR
33	210323	1	LONG HANGER, M/F PLATE 3/16 THK	CRES	ASTM-A240	N/A	1.75	FAIRLEAD PRECISION, SEE SH 10
34	330001	10	SURFACE MOUNT ROPE RING, 12,000 LB WORKING LIMIT	VARIOUS	COML	N/A	0.78	MAC'S CUSTOM TIE DOWNS
37	314139	1	TOTE, 50 GALLON	VARIOUS	COML	N/A	10	CENTREX PLASTICS
38	210329	2	CANTILEVER BHD MOUNTING ARM, M/F PLATE 3/16 THK	CRES	ASTM-A240	N/A	13.25	FAIRLEAD PRECISION, SEE SH 11
39	210318	5	SHORT HANGER, M/F PLATE 3/16 THK	CRES	ASTM-A240	N/A	1.15	FAIRLEAD PRECISION, SEE SH 12
40	210635	1	LABEL KIT	ALUMINUM	COML	N/A	1	FAIRLEAD PRECISION, SEE SH 13, NOTE 7, AND 13
41	RS1N	3	STRAP, RATCHET, S-HOOKS, 24 LG, BLK	VARIOUS	COML	N/A	0.25	STRAPWORKS
42	MSN1012	2	LABEL, NO SMOKING	VARIOUS	COML	N/A	0.1	ACCUFORM, SEE NOTE 9
43	ILS-90-04	2	WARNING LABEL	VARIOUS	COML	N/A	0.1	ADVANCED DESIGN, SEE NOTE 10, 12, AND SH 13
44	210652	1	HEATER STOP	ALUMINUM	COML	N/A	1.1	FAIRLEAD PRECISION, SEE SHEET 12
45	N/A	1	BLOWER EXTENSIONS	VARIOUS	COML	N/A	N/A	STORED IN CONTAINER 1, TOTE 1
46	N/A	1	SHOP VAC HOSE	VARIOUS	COML	N/A	N/A	STORED IN CONTAINER 1, TOTE 1
47	N/A	1	SHOP VAC ACCESSORIES KIT	VARIOUS	COML	N/A	N/A	STORED IN CONTAINER 1, TOTE 1
48	107902	1	SUCTION HOSE STRAINER, METAL	VARIOUS	COML	N/A	N/A	NOTHERN TOOL AND EQUIPMENT
49	203167415	1	SHOVEL, CHARCOAL/ASH	ALUMINUM	COML	N/A	N/A	RAUCHLEN
50	210653	2	CONTENTS LABEL	VARIOUS	COML	N/A	N/A	ADVANCED DESIGN, SEE NOTE 16 AND SHEET 16



SIZE:	CAGE CODE:	DRAWING NO.:	REV.:
B	N/A	210630	C
SCALE: NONE		WT: N/A	SHEET 3 OF 15



6 5 4 3 2 1

**TABLE 4-5D**  
LIST OF MATERIAL REQUIRED FOR (1) BASKET 1

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL	MATL SPEC	NSN NO	WEIGHT (POUNDS)	NOTES
6	2052	36	CONTAINMENT DIKE, 10 FT LG	VARIOUS	COML	7950-01-436-8320	13	ULTRA-SPILL BERM
8	CF020B	2	PLASTIC SHEETING, 20 FT X 100 FT	VARIOUS	COML	8135-00-579-6487	29	AIRGAS
9	B461657	10	TARPAULIN	VARIOUS	COML	8340-01-487-5610	45	GLOBAL INDUSTRIAL
18	INAWB400	44	TENT ANCHOR BAGS	VARIOUS	COML	N/A	2.1	KING CANOPY
24	FEL2667C240	5	TIE DOWN, CARGO AIRCRAFT	VARIOUS	COML	1670-00-725-1437	3.9	KINEDYNE
31	5066172	1	WIRE BASKET (48 X 40 X 42)	STEEL	COML	N/A	166	MCMMASTER CARR

**TABLE 4-5C**  
LIST OF MATERIAL REQUIRED FOR (1) BASKET 2

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL	MATL SPEC	NSN NO	WEIGHT (POUNDS)	NOTES
3	N/A	18	FIRE HOSE, CUSTOM, 30 FT LG	VARIOUS	COML	N/A	26	FLORIDA HOSE AND RUBBER, SEE NOTE 6 AND 15
4	DC250A	18	2-1/2" DUST CAP	VARIOUS	COML	N/A	0.94	FLORIDA HOSE AND RUBBER, SEE NOTE 15
5	DP250A	18	2-1/2" DUST PLUG	VARIOUS	COML	N/A	0.54	FLORIDA HOSE AND RUBBER, SEE NOTE 15
7	H-3912P510	4	NO. 10 SIEVE	VARIOUS	COML	N/A	4	HUMBOLDT
9	B461657	14	TARPAULIN	VARIOUS	COML	8340-01-487-5610	45	GLOBAL INDUSTRIAL
30	5066132	1	WIRE BASKET (48 X 40 X 36)	STEEL	COML	N/A	140	MCMMASTER CARR

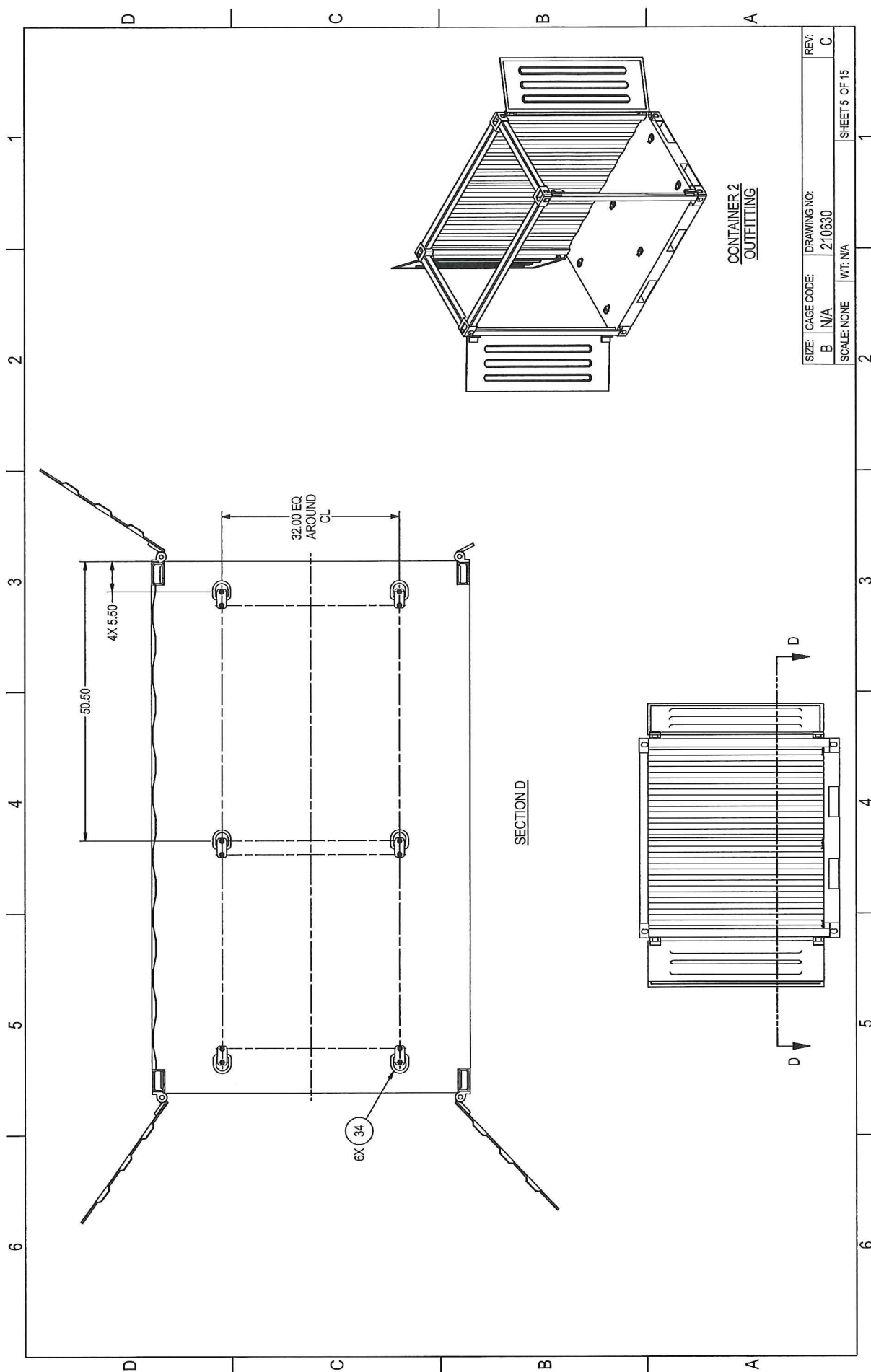
**TABLE 4-5B**  
LIST OF MATERIAL REQUIRED FOR (1) BASKET 3

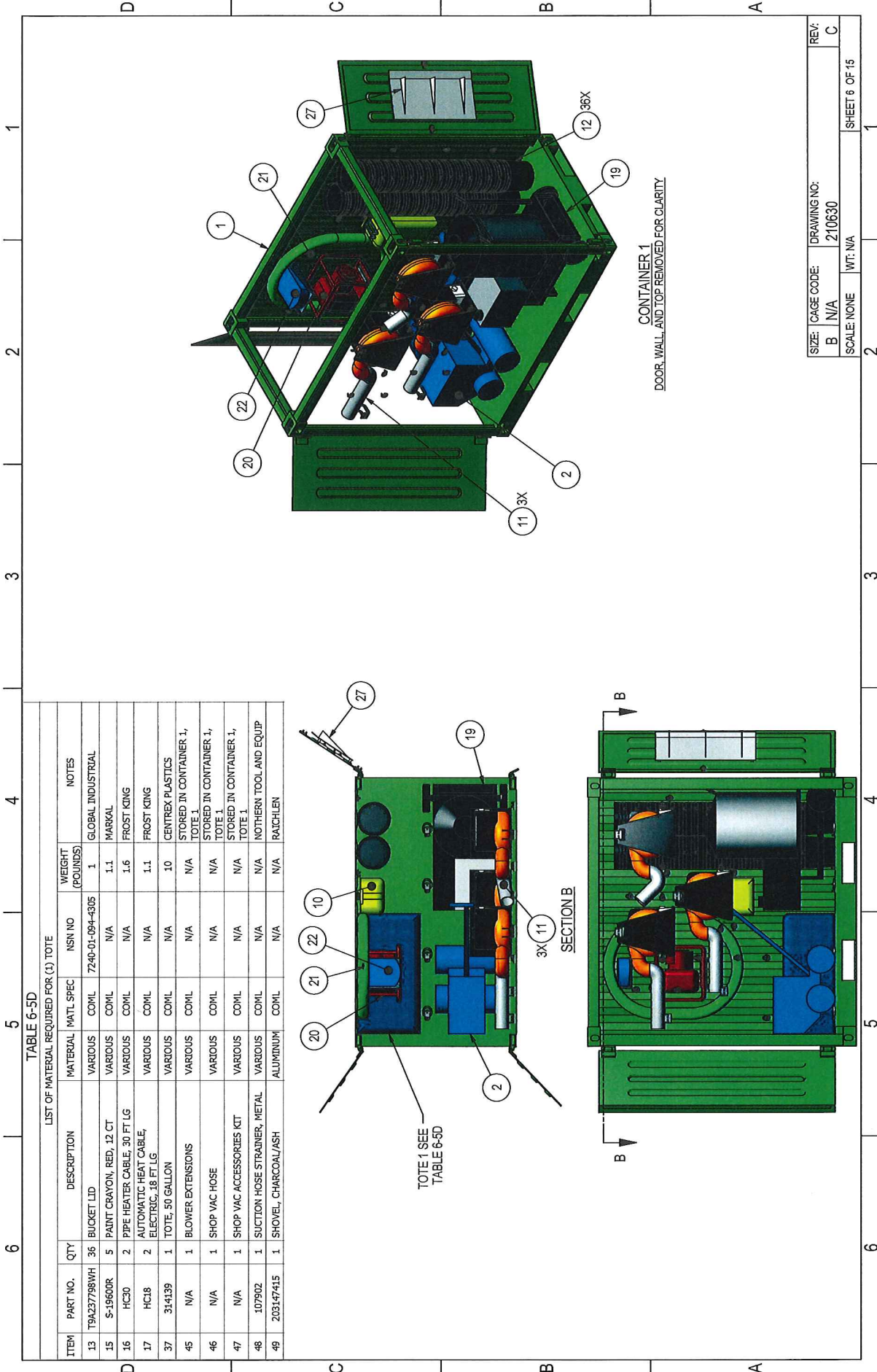
ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL	MATL SPEC	NSN NO	WEIGHT (POUNDS)	NOTES
14	AF10X10	10	POP UP TENT	VARIOUS	COML	N/A	90	PROMOTIONAL DESIGN GROUP
31	5066172	1	WIRE BASKET (48 X 40 X 42)	STEEL	COML	N/A	166	MCMMASTER CARR

SIZE: CAGE CODE: DRAWING NO: REV:  
 B N/A 210630 C  
 SCALE: NONE WGT: N/A SHEET 4 OF 15

D C B A

D C B A



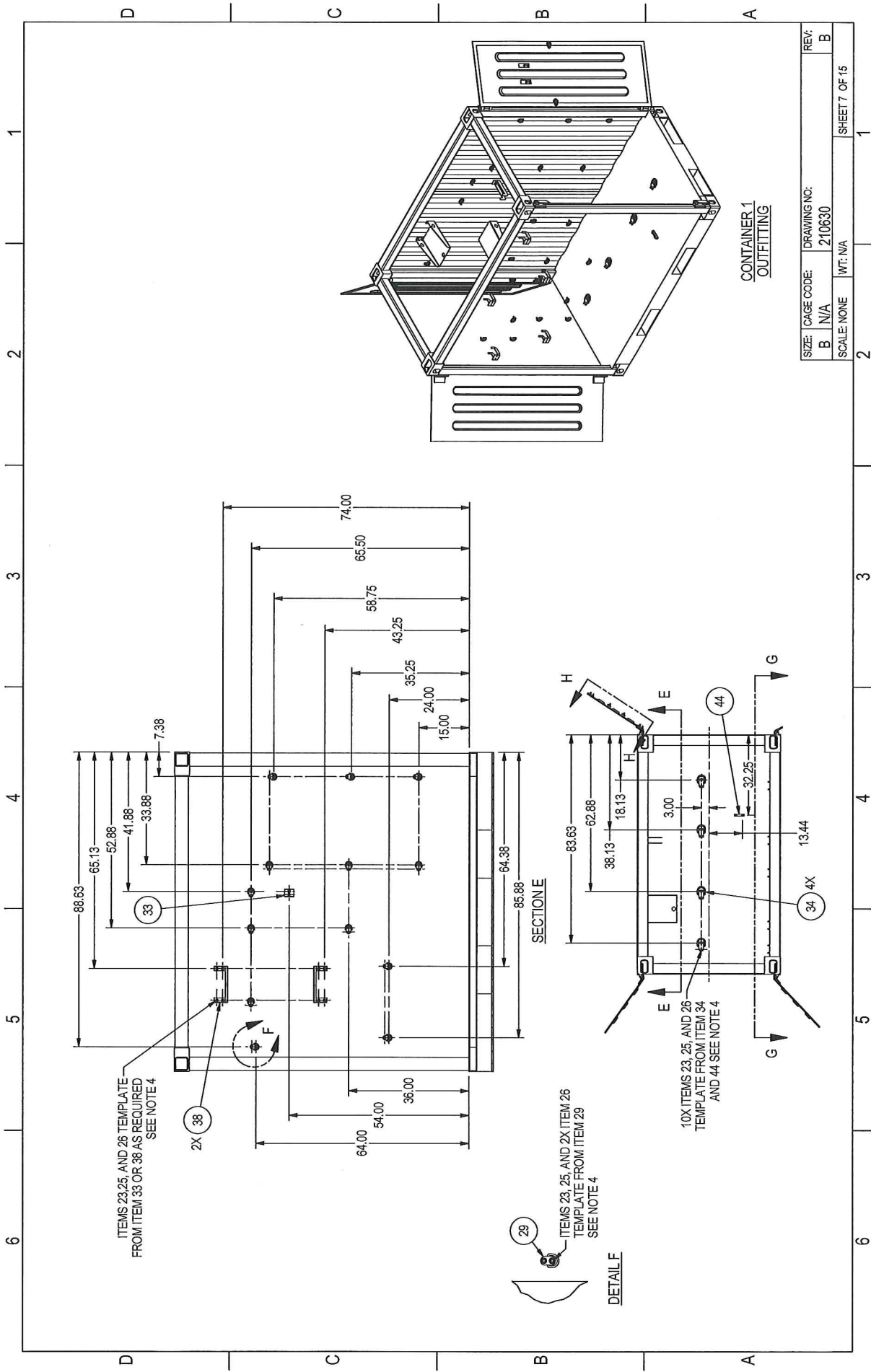


CONTAINER 1  
DOOR, WALL, AND TOP REMOVED FOR CLARITY

**TABLE 6-5D**  
LIST OF MATERIAL REQUIRED FOR (1) TOTE

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL	MATL. SPEC	NSN NO	WEIGHT (POUNDS)	NOTES
13	TS9A23798WH	36	BUCKET LID	VARIOUS	COML	7240-01-094-4305	1	GLOBAL INDUSTRIAL
15	S-19600R	5	PAINT CRAYON, RED, 12 CT	VARIOUS	COML	N/A	1.1	MARKAL
16	HC30	2	PIPE HEATER CABLE, 30 FT LG	VARIOUS	COML	N/A	1.6	FROST KING
17	HC18	2	AUTOMATIC HEAT CABLE, ELECTRIC, 18 FT LG	VARIOUS	COML	N/A	1.1	FROST KING
37	314139	1	TOTE, 50 GALLON	VARIOUS	COML	N/A	10	CENTREX PLASTICS STORED IN CONTAINER 1, TOTE 1
45	N/A	1	BLOWER EXTENSIONS	VARIOUS	COML	N/A	N/A	STORED IN CONTAINER 1, TOTE 1
46	N/A	1	SHOP VAC HOSE	VARIOUS	COML	N/A	N/A	STORED IN CONTAINER 1, TOTE 1
47	N/A	1	SHOP VAC ACCESSORIES KIT	VARIOUS	COML	N/A	N/A	STORED IN CONTAINER 1, TOTE 1
48	107902	1	SUCTION HOSE STRAINER, METAL	VARIOUS	COML	N/A	N/A	NORTHERN TOOL AND EQUIP
49	203147415	1	SHOVEL, CHARCOAL/ASH	ALUMINUM	COML	N/A	N/A	RAICHLEN

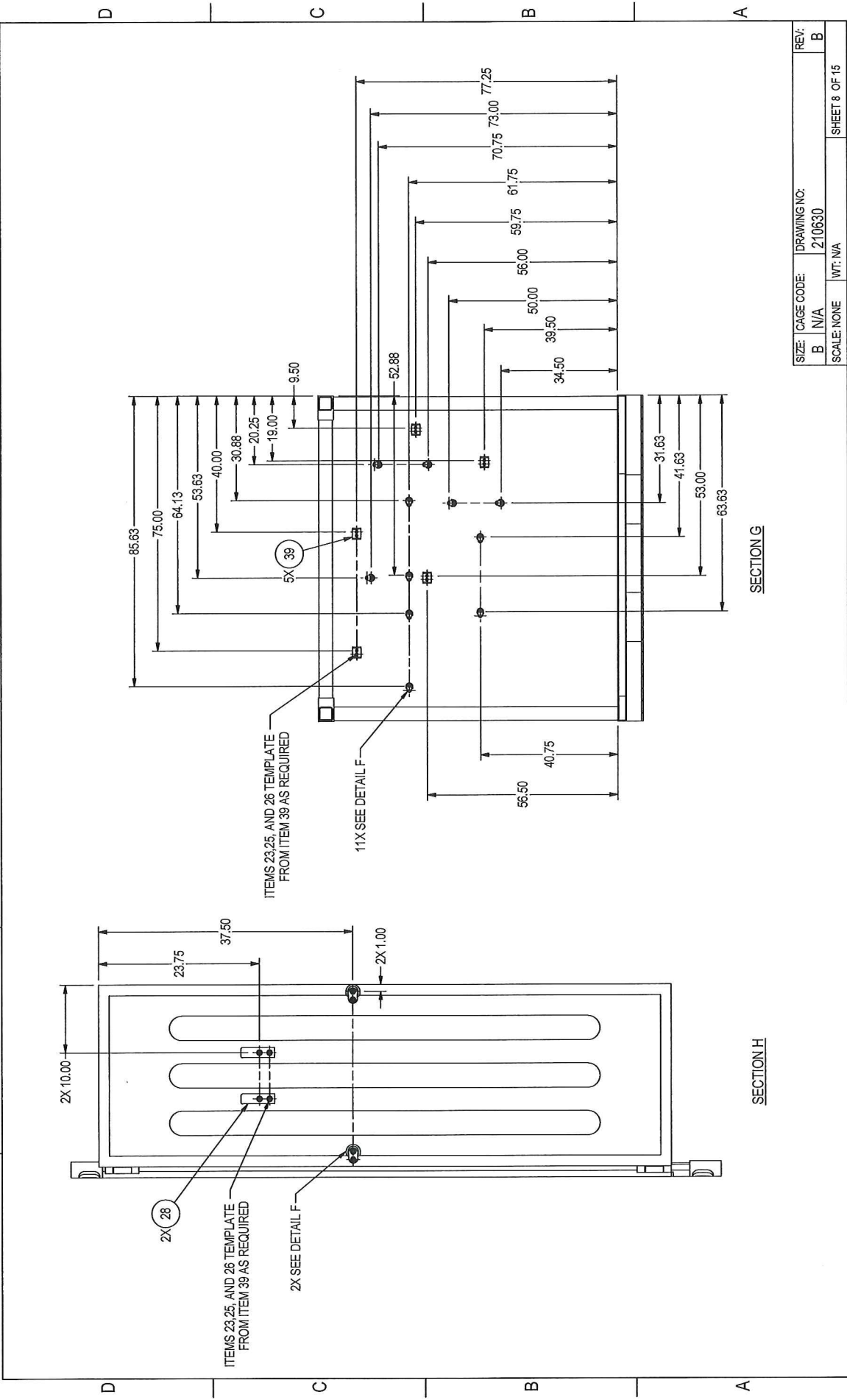
SIZE:	CAGE CODE:	DRAWING NO:	REV:
B	N/A	210630	C
SCALE:	NONE	WGT:	N/A
		SHEET 6 OF 15	



CONTAINER 1  
OUTFITTING

SIZE:	CAGE CODE:	DRAWING NO.:	REV.:
B	N/A	210630	B
SCALE: NONE		WT: N/A	SHEET 7 OF 15

1 2 3 4 5 6



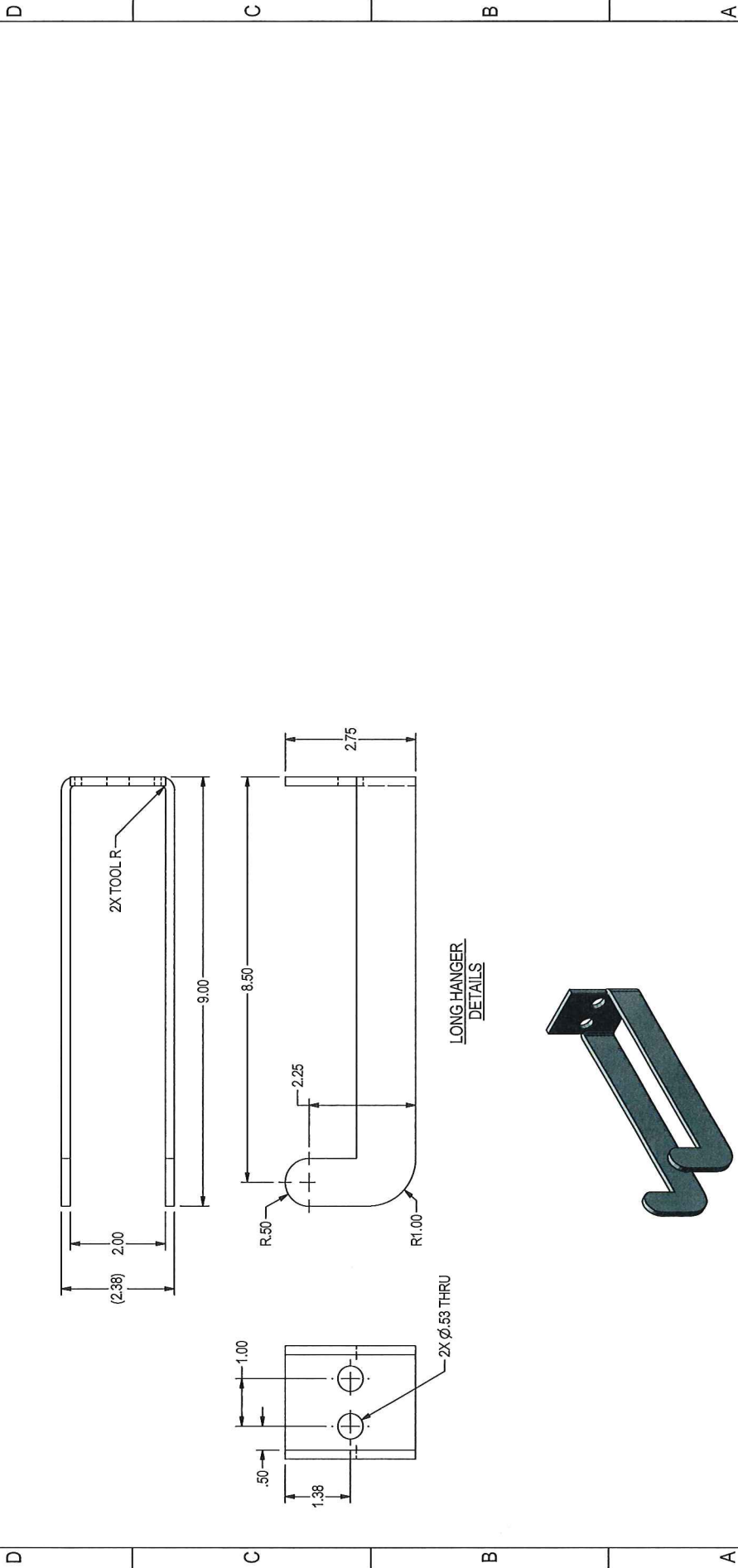
SECTION G

SECTION H

SIZE:	CAGE CODE:	DRAWING NO:	REV:
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SCALE:	NONE	WT: N/A	SHEET 8 OF 15

2 3 4 5 6

1 2 3 4 5 6

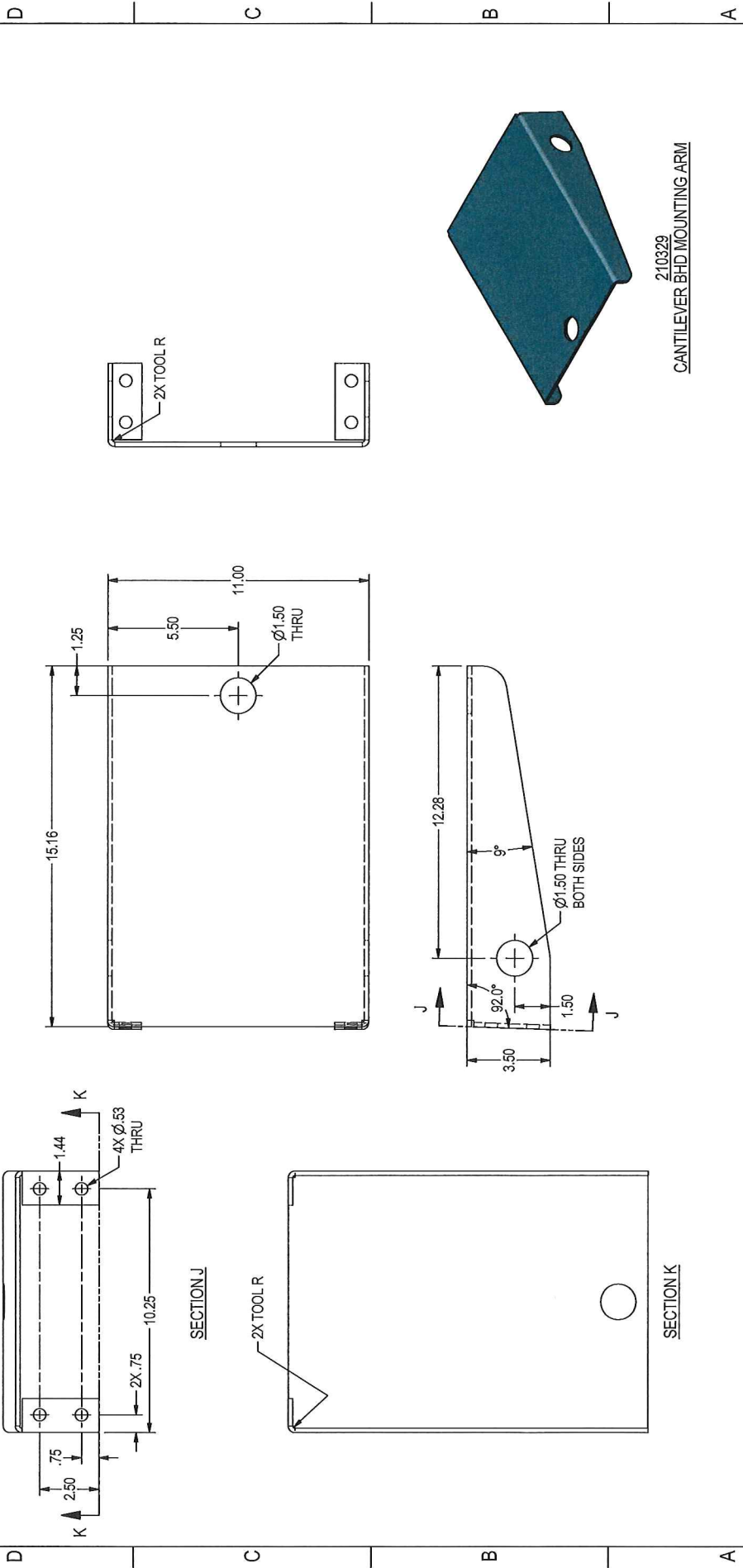


LONG HANGER  
DETAILS

210323  
LONG HANGER

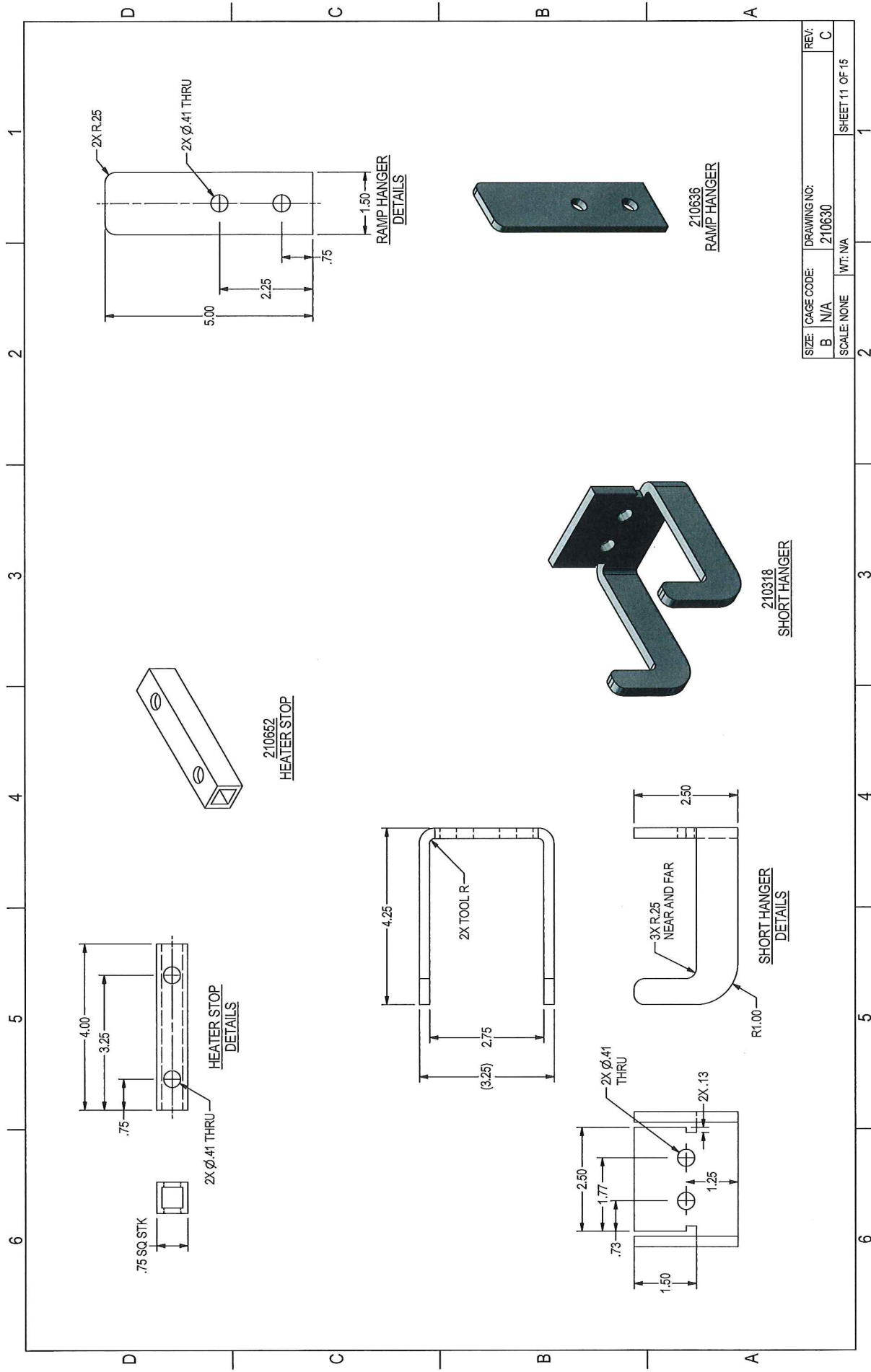
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B	N/A	210630	C
SCALE: NONE		WT: N/A	SHEET 9 OF 15

1 2 3 4 5 6



210329  
CANTILEVER BHD MOUNTING ARM

SIZE:	CAGE CODE:	DRAWING NO.:	REV.:
B	N/A	210630	B
SCALE: NONE		WT: N/A	SHEET 10 OF 15



SIZE:	CAGE CODE:	DRAWING NO:	REV:
B	N/A	210630	C
SCALE: NONE		WT: N/A	SHEET 11 OF 15



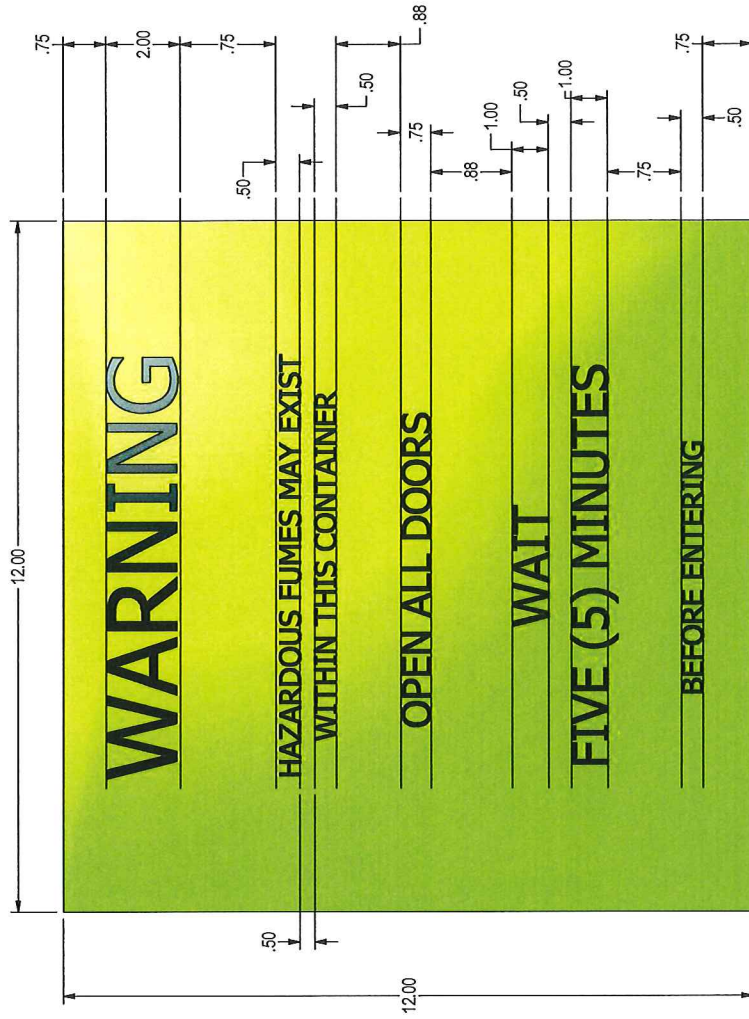
1 2 3 4 5 6

WEATHER BASKET 1		
ITEM	PART NO.	DESCRIPTION
6	2052	36 CONTAINMENT DIKE, 10 FT LG.
8	CP0620B	2 PLASTIC SHEETING, 20 FT X 100 FT
9	B461657	10 TARP AULIN
18	INAWB400	44 TENT ANCHOR BAGS
24	FEL2687C240	5 TIE DOWN, CARGO, AIRCRAFT

WEATHER BASKET 2		
ITEM	PART NO.	DESCRIPTION
3	N/A	FIRE HOSE, CUSTOM, 30 FT LG; NOTE: FIRE HOSE IS ASSEMBLED CONSISTING OF ITEMS 3, 4, AND 5
4	DC250A	18 2-1/2" DUST CAP
5	DP250A	18 2-1/2" DUST PLUG
7	H-3912FS10	4 NO. 10 SIEVE
9	B461657	14 TARP AULIN

WEATHER BASKET 3		
ITEM	PART NO.	DESCRIPTION
14	AF10X10	10 POP UP TENT

WEATHER TOTE 1		
ITEM	PART NO.	DESCRIPTION
13	T9A23758WH	36 BUCKET LID
15	S-15600R	5 PAINT CRAYON, RED, 13 CT
16	HC30	2 PIPE HEATER CABLE, 30 FT LG
17	HC18	2 AUTOMATIC HEAT CABLE, ELECTRIC, 18 FT LG
45	N/A	1 BLOWER EXTENSIONS
46	N/A	1 SHOP VAC HOSE
47	N/A	1 SHOP VAC ACCESSORIES KIT
48	107902	1 SUCTION HOSE STRAINER, METAL
49	203147415	1 SHOVEL, CHARCOAL/ASH

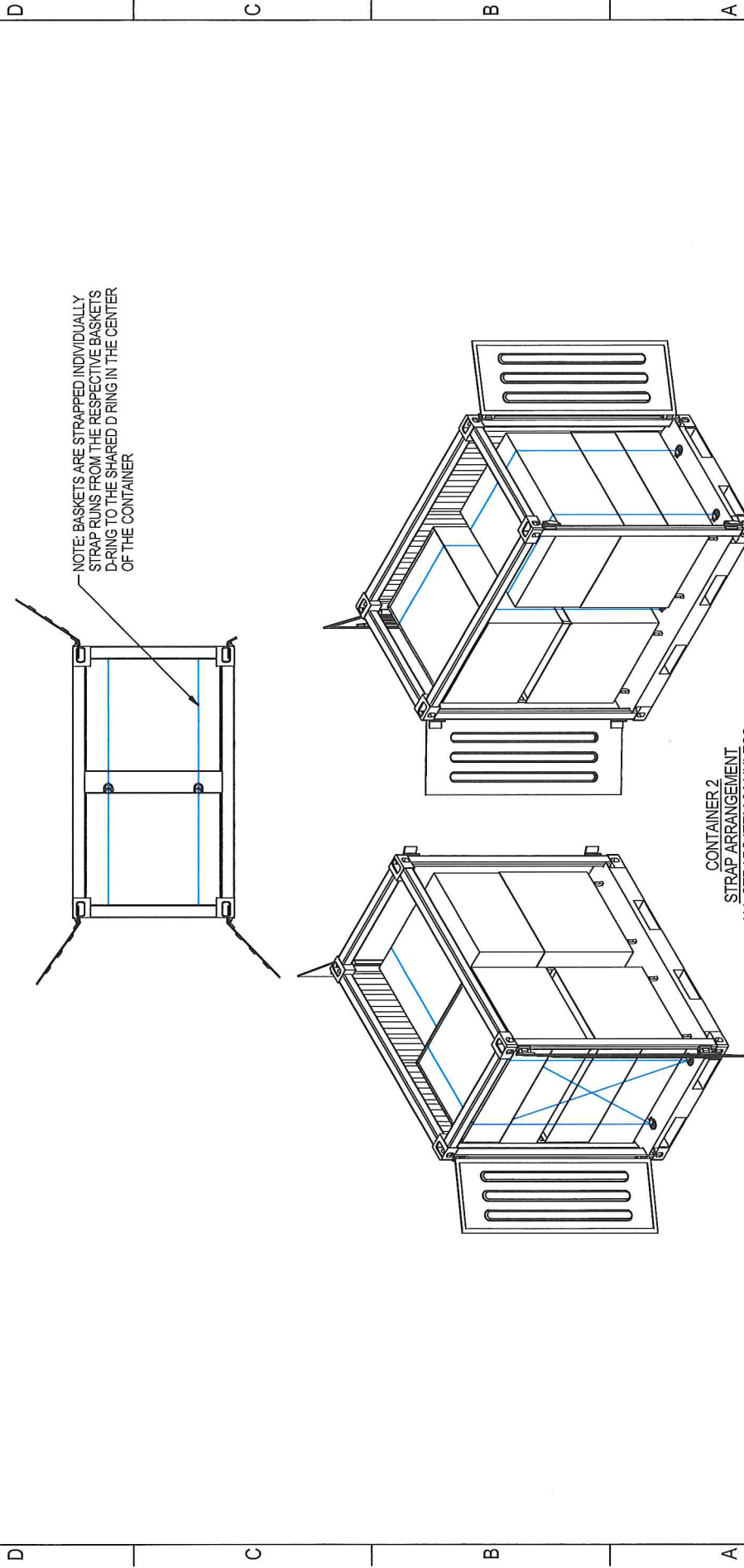


ILS-94-04  
WARNING LABEL  
 SEE NOTE 12  
NOT TO SCALE

SIZE:	CAGE CODE:	DRAWING NO.:	REV.:
B	N/A	210630	C
SCALE: NONE		WT: N/A	SHEET 12 OF 15

1 2 3 4 5 6

1 2 3 4 5 6

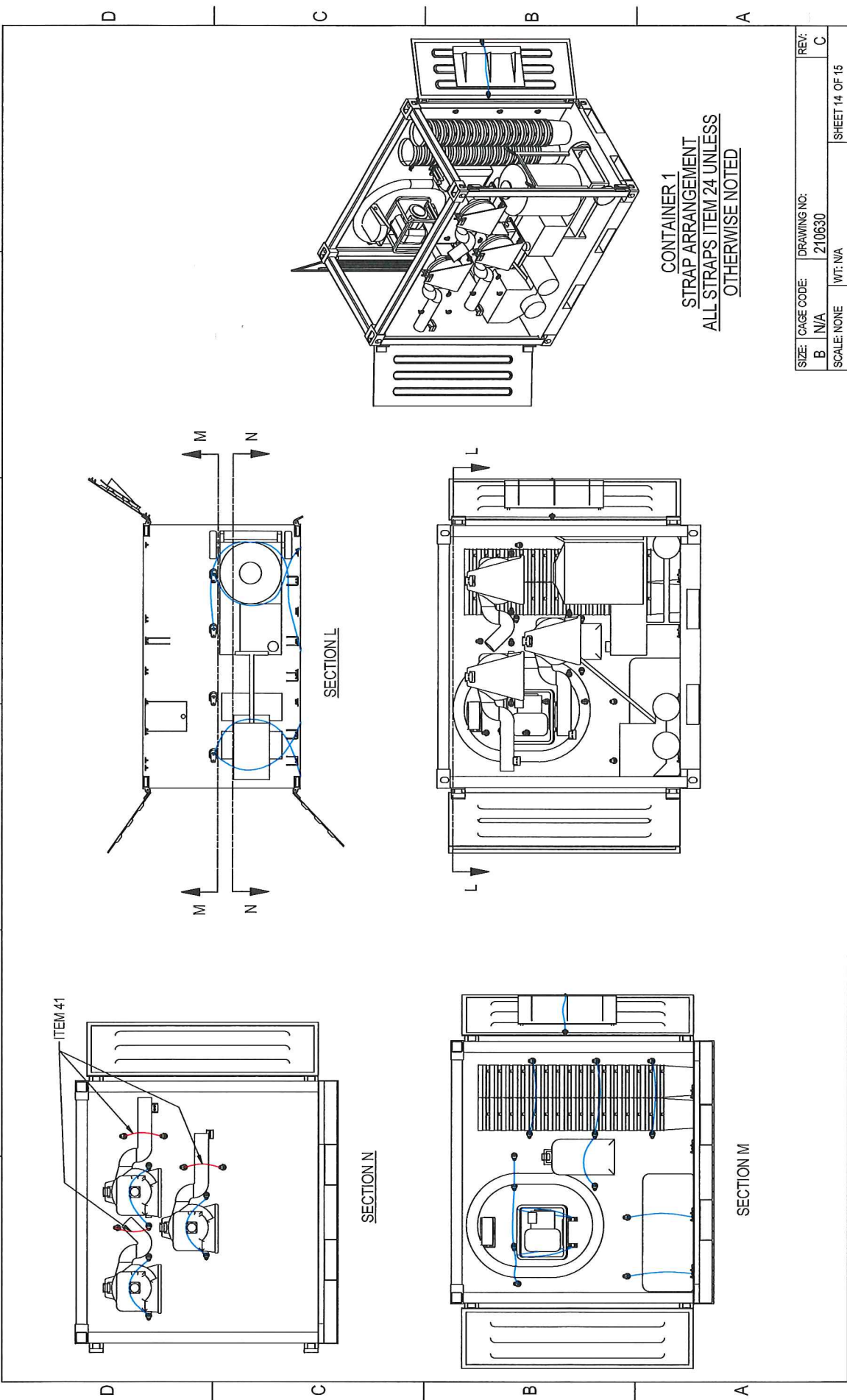


NOTE: BASKETS ARE STRAPPED INDIVIDUALLY  
 STRAP RUNS FROM THE RESPECTIVE BASKETS  
 D-RING TO THE SHARED D RING IN THE CENTER  
 OF THE CONTAINER

CONTAINER 2  
 STRAP ARRANGEMENT  
 ALL STRAPS ITEM 24 UNLESS  
 OTHERWISE NOTED

SIZE:	CAGE CODE:	DRAWING NO.:	REV.:
B	N/A	210630	C
SCALE: NONE		WT: N/A	SHEET 13 OF 15

1 2 3 4 5 6



CONTAINER 1  
 STRAP ARRANGEMENT  
 ALL STRAPS ITEM 24 UNLESS  
 OTHERWISE NOTED

SIZE:	CAGE CODE:	DRAWING NO.:	REV.:
B	N/A	210630	C
SCALE:	NONE	WT: N/A	SHEET 14 OF 15

6 5 4 3 2 1

CONTAINER 1 CONTENTS

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL	MATL SPEC	NSN NO	WEIGHT (POUNDS)	NOTES
2	BBDDM10	1	LINE MARKER	VARIOUS	COML	N/A	58	MARKERS INC.
10	394-20-00	1	VACUUM	VARIOUS	COML	N/A	16	SHOP-VAC
11	350BT	3	BACKPACK BLOWER	VARIOUS	COML	3750-01-480-0543	22.5	HUSQVARNA
12	T9A237797WH	36	5 GALLON BUCKET	VARIOUS	COML	7240-01-094-4305	2.1	GLOBAL INDUSTRIAL
13	T9A237798WH	36	BUCKET LID	VARIOUS	COML	7240-01-094-4305	1	GLOBAL INDUSTRIAL
15	S-1960UR	5	PAINT CRAYON, RED, 12 CT	VARIOUS	COML	N/A	1.1	MARKAL
16	HC30	2	PIPE HEATER CABLE, 30 FT LG	VARIOUS	COML	N/A	1.6	FROST KING
17	HC18	2	AUTOMATIC HEAT CABLE, ELECTRIC, 18 FT LG	VARIOUS	COML	N/A	1.1	FROST KING
19	FSI HEAT 200 A	1	INLINE WATER HEATER	VARIOUS	COML	N/A	330	FSI NORTH AMERICA
20	WB20XT3	1	WATER PUMP	VARIOUS	COML	N/A	57	HONDA
21	HP03205	1	SUCTION HOSE, 20 FT LG	VARIOUS	COML	N/A	24	MAX TOOL
22	HP03500	1	DISCHARGE HOSE, 50 FT LG	VARIOUS	COML	N/A	18	MAX TOOL
27	2187733	1	RAMP, 36" WIDE X 18" LONG	ALUMINIUM	COML	N/A	16	MCMASTER CARR
37	31-4139	1	TOTE, 50 GALLON	VARIOUS	COML	N/A	10	CENTREX PLASTICS
45	N/A	1	BLOWER EXTENSIONS	VARIOUS	COML	N/A	N/A	STORED IN CONTAINER 1, TOTE 1
46	N/A	1	SHOP VAC HOSE	VARIOUS	COML	N/A	N/A	STORED IN CONTAINER 1, TOTE 1
47	N/A	1	SHOP VAC ACCESSORIES KIT	VARIOUS	COML	N/A	N/A	STORED IN CONTAINER 1, TOTE 1
48	107902	1	SUCTION HOSE STRAINER, METAL	VARIOUS	COML	N/A	N/A	NORTHERN TOOL AND EQUIP
49	203147415	1	SHOVEL, CHARCOAL/ASH	ALUMINIUM	COML	N/A	N/A	RAICHLEN

CONTAINER 2 CONTENTS

ITEM	PART NO.	QTY	DESCRIPTION	MATERIAL	MATL SPEC	NSN NO	WEIGHT (POUNDS)	NOTES
3	210632	18	FIRE HOSE, CUSTOM, 30 FT LG	VARIOUS	COML	N/A	26	FLORIDA HOSE AND RUBBER, SEE NOTE 6 AND 15
4	DC250A	18	2-1/2" DUST CAP	VARIOUS	COML	N/A	0.94	FLORIDA HOSE AND RUBBER, SEE NOTE 15
5	DP250A	18	2-1/2" DUST PLUG	VARIOUS	COML	N/A	0.54	FLORIDA HOSE AND RUBBER, SEE NOTE 15
6	2052	36	CONTAINMENT DIKE, 10 FT LG	VARIOUS	COML	7930-01-436-8320	13	ULTRA-SPILL BERM
7	H-3912FS10	4	NO. 10 SIEVE	VARIOUS	COML	N/A	4	HUMBOLDT
8	CF0620B	2	PLASTIC SHEETING, 20 FT X 100 FT	VARIOUS	COML	8135-00-579-6487	29	AIRGAS
9	B461657	24	TARPAULIN	VARIOUS	COML	8340-01-487-5610	45	PROMOTIONAL DESIGN GROUP
14	AF10X10	10	POP UP TENT	VARIOUS	COML	N/A	90	GLOBAL INDUSTRIAL
18	INAWB400	11	TENT ANCHOR BAGS	VARIOUS	COML	N/A	2.1	KING CANOPY
24	FEL2687C240	5	TIE DOWN, CARGO, AIRCRAFT	VARIOUS	COML	1670-00-725-1437	3.9	KINEDYNE
30	5066732	1	WIRE BASKET (48 X 40 X 36)	STEEL	COML	N/A	140	MCMASTER CARR
31	5066772	2	WIRE BASKET (48 X 40 X 42)	STEEL	COML	N/A	166	MCMASTER CARR

SIZE:	CAGE CODE:	DRAWING NO.:	REV.:
B	N/A	210630	C
SCALE:	NONE	WT: N/A	SHEET 15 OF 15

# REPORT DOCUMENTATION PAGE

*Form Approved*  
**OMB No. 0704-0188**

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<b>1. REPORT DATE (DD-MM-YYYY)</b> November 2017		<b>2. REPORT TYPE</b> Final		<b>3. DATES COVERED (From - To)</b>		
<b>4. TITLE AND SUBTITLE</b>  Inclement Weather Crater Repair Tool Kit				<b>5a. CONTRACT NUMBER</b>		
				<b>5b. GRANT NUMBER</b>		
				<b>5c. PROGRAM ELEMENT NUMBER</b>		
<b>6. AUTHOR(S)</b>  Haley P. Bell and Jeb S. Tingle				<b>5d. PROJECT NUMBER</b> 333159		
				<b>5e. TASK NUMBER</b>		
				<b>5f. WORK UNIT NUMBER</b>		
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b>  Geotechnical and Structures Laboratory U.S. Army Engineer Research and Development Center 3909 Halls Ferry Road Vicksburg, MS 39180-6199				<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>  ERDC/GSL TR-17-26		
<b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> Headquarters, U.S. Air Force Civil Engineer Center Tyndall Air Force Base, FL 32403-5319				<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b> AFCEC		
				<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>		
<b>12. DISTRIBUTION / AVAILABILITY STATEMENT</b> Approved for public release; distribution is unlimited.						
<b>13. SUPPLEMENTARY NOTES</b>						
<b>14. ABSTRACT</b>  During the period October 2015 through May 2016, the U.S. Army Engineer Research and Development Center (ERDC) in Vicksburg, MS, worked to develop a prototype tool kit comprised of equipment and materials needed to repair concrete and asphalt craters on airfield pavements during times of inclement weather. The tool kit is used to supplement an existing crater repair tool kit developed for fair weather scenarios. The items selected for inclusion in the kit were based on previous research and evaluation of crater repair methods and during specific full-scale inclement weather crater repair experiments. This report presents a summary of the research conducted to help determine the prototype Inclement Weather Crater Repair Tool Kit contents and also presents the specific details of the kit, including inventory and drawings.						
<b>15. SUBJECT TERMS</b> Runways (Aeronautics) – maintenance and repair Tools Rain and rainfall			Airfield damage repair Crater Blast effect Cold weather operation	Inclement weather Repair kit Cratering		
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>	<b>18. NUMBER OF PAGES</b>	<b>19a. NAME OF RESPONSIBLE PERSON</b>	
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