



NATIONAL TRANSPORTATION SAFETY BOARD  
**Investigative Hearing**

Norfolk Southern Railway general merchandise freight train 32N  
derailment with subsequent hazardous material release and fires,  
in East Palestine, Ohio, on February 3, 2023

<b>GROUP</b>	<b>H</b>
<b>EXHIBIT</b>	
19	

Agency / Organization

**Norfolk Southern**

Title

**DOT FRA Handbook for Vent and Burn  
Method of Field Product Removal  
(May 1994)**



U.S. Department  
of Transportation  
**Federal Railroad  
Administration**

# **HANDBOOK FOR VENT AND BURN METHOD OF FIELD PRODUCT REMOVAL**

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Office of Research and  
Development  
Washington D.C. 20590

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DOT/FRA/ORD-94/18

May 1994  
Final Report

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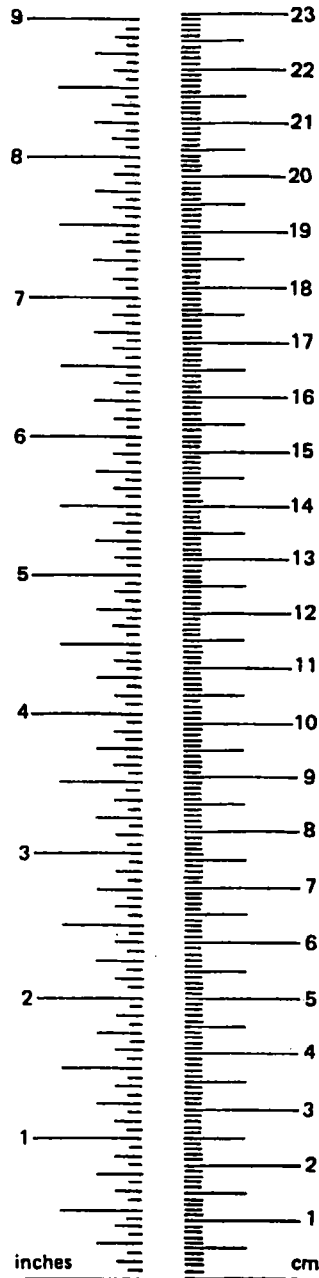
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## METRIC CONVERSION FACTORS

### Approximate Conversions to Metric Measures

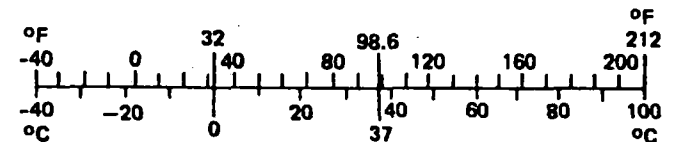
Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
in	inches	*2.50	centimeters	cm
ft	feet	30.00	centimeters	cm
yd	yards	0.90	meters	m
mi	miles	1.60	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	6.50	square centimeters	cm <sup>2</sup>
ft <sup>2</sup>	square feet	0.09	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yards	0.80	square meters	m <sup>2</sup>
mi <sup>2</sup>	square miles	2.60	square kilometers	km <sup>2</sup>
	acres	0.40	hectares	ha
<b>MASS (weight)</b>				
oz	ounces	28.00	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.90	tonnes	t
<b>VOLUME</b>				
tsp	teaspoons	5.00	milliliters	ml
Tbsp	tablespoons	15.00	milliliters	ml
fl oz	fluid ounces	30.00	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.80	liters	l
ft <sup>3</sup>	cubic feet	0.03	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.76	cubic meters	m <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

\* 1 in. = 2.54 cm (exactly)



### Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
mm	millimeters	0.04	inches	in
cm	centimeters	0.40	inches	in
m	meters	3.30	feet	ft
m	meters	1.10	yards	yd
km	kilometers	0.60	miles	mi
<b>AREA</b>				
cm <sup>2</sup>	square centim.	0.16	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	1.20	square yards	yd <sup>2</sup>
km <sup>2</sup>	square kilom.	0.40	square miles	mi <sup>2</sup>
ha	hectares (10,000 m <sup>2</sup> )	2.50	acres	
<b>MASS (weight)</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
<b>VOLUME</b>				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.10	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m <sup>3</sup>	cubic meters	36.00	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.30	cubic yards	yd <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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16. Abstract <p>The Federal Railroad Administration tasked the Association of American Railroads (AAR), Transportation Test Center Hazardous Materials Training Center (TTC) to research and develop safe, reliable operating procedures for the Vent and Burn method of field product removal, and to define when or if this procedure should be used in the event of tank car derailments involving hazardous materials. The Vent and Burn procedure uses explosive charges to cut holes in the damaged tank car to relieve internal vapor pressure and subsequently drain the liquid product from the car for destruction. Vent and Burn is inherently dangerous and other methods of field product removal or car rerailment must be considered first. This procedure is applicable to some compressed gases and some flammable or combustible liquids shipped in pressure or general service tank cars. This handbook describes the Vent and Burn procedure in a step-wise manner. It is intended to help emergency responders to understand the procedure, its limitations, inherent risks and the application principles of this method. The emergency explosives expert responder can use this handbook as a guide to apply explosive charges onto the car for successful results. The proposed hole cutting technique described in this handbook has been proven by testing at AAR/TTC. Please refer to DOT/FRA/ORD/94-17 for detailed experimental results.</p>					
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## LIST OF ABBREVIATIONS

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- AAR - Association of American Railroads
- DOT - Department of Transportation
- ECT - Explosive Cutting Tape
- FAA - Federal Aviation Administration
- FRA - Federal Railroad Administration
- gr/ft - Grains per foot
- LEPC - Local Emergency Planning Committee
- NAX - North American Explosives
- RDX - An explosive composed of Cyclonite (cyclo-1,3,5-trimethylene-2,4,6-trinitramine), Trimethyltrinitramine, and Hexagene
- TC - Transport Canada
- TTC - Transportation Test Center

## TABLE OF CONTENTS

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OVERVIEW .....	1
REASONS FOR SELECTING THE VENT AND BURN METHOD .....	3
PREFERRED CONDITIONS .....	3
INHERENT RISKS .....	4
CANDIDATE PRODUCTS .....	5
CANDIDATE TANK CARS .....	6
PRESSURE CARS .....	6
GENERAL SERVICE CARS .....	9
SAFETY PRECAUTIONS .....	11
REQUIRED EQUIPMENT .....	13
EXPLOSIVE CHARGES .....	15
GENERAL PROCEDURES .....	20
PREPARATION FOR VENT AND BURN .....	20
PIT CONSTRUCTION .....	23
SITE PREPARATION .....	24
REMOVING TANK JACKET .....	26
VENT AND DRAIN HOLES .....	28
SHUT DOWN THE VENT AND BURN OPERATION .....	31
PROBLEMS DURING VENT AND BURN .....	32
APPENDIX A -- EXPLOSIVES RESOURCES .....	33
APPENDIX B -- LITERATURE SEARCH .....	35

## LIST OF FIGURES

---

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Figure 1. Schematic of Tank Car Displaying Vapor and Liquid Spaces; Recommended Application Points of Explosives Indicated .....	1
Figure 2. Application of Vent and Burn Procedure on Flammable or Combustible Liquid .....	2
Figure 3. Trapezoidal Head Shield on Tank Car .....	6
Figure 4. Typical Layers of Jacketing, Insulation, Thermal Protection, and Tank Shell on Tank Car .....	8
Figure 5. Heater Pipes Located Beneath Jacketing on Some Candidate Tank Cars .....	10
Figure 6. Construction of Tank Cutting Charge with Detonation Sheet, Retaining Ring, and Blasting Caps .....	18
Figure 7. Desired and Rolled Orientation of Tank Cutting Charge ..	19
Figure 8. Vent and Burn Performed with Compressed Gas -- Pit Near Tank Car .....	22

## LIST OF TABLES

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Table 1. Recommended Charge Material, Strengths, and Sizing .....	17
---	----



## FOREWORD

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This handbook presents the Vent and Burn method for unloading damaged railroad tank cars in the field. The procedures follow the conclusions and recommendations published in report DOT/FRA/ORD/94-17, entitled "Vent and Burn Method of Field Product Removal." The handbook is presented in similar format to another report, DOT/FRA/92-27, entitled "Field Product Removal Methods for Tank Cars."

The Vent and Burn procedure involves the use of explosive charges to cut holes in the damaged tank car -- one hole to relieve excessive internal vapor pressure in the tank, and another to drain the liquid product from the tank car for disposal by burning. This document attempts to explain the Vent and Burn procedure so that it may be performed as safely as possible. It is intended to help emergency responders to understand the procedure, its limitations, inherent risks, and the application principles for this method.

The reader should note that this handbook describes typical equipment and procedures that might be used in any given operation. Actual equipment and procedures used may vary according to the product lading, the tank car specification, and other factors unique to the situation at hand.

The proposed hole cutting technique described in this handbook has been proven by testing at the Association of American Railroads' (AAR) Transportation Test Center in Pueblo, Colorado. The testing has refined this method to be more specific in procedure and more predictable in outcome.

The emergency explosives expert responder can use this handbook as a guide to apply explosive charges onto the car for successful results. The local emergency planning committee (LEPC) that plans to use this method should maintain a resource list containing the location of the nearest explosives technician and recommended explosives supplier.

*THERE IS NO SUBSTITUTE FOR THE GOOD JUDGEMENT  
OF THOSE IN THE FIELD.*

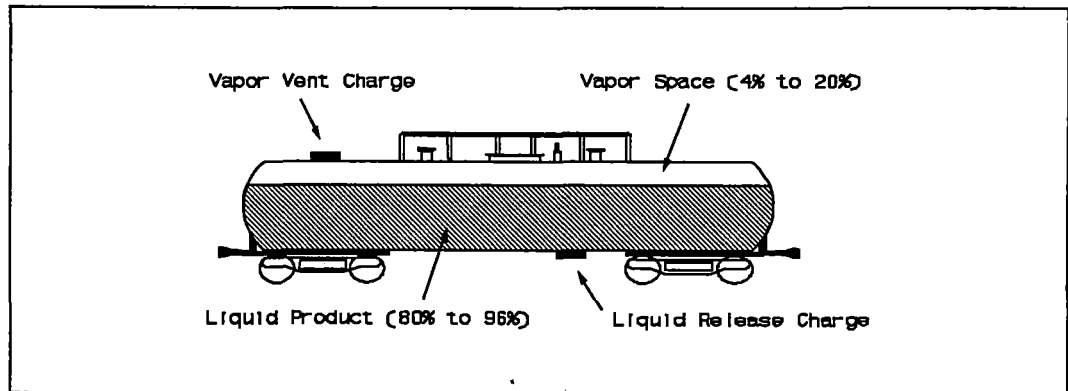
## OVERVIEW

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### DEFINITION OF VENT AND BURN

Vent and Burn is an emergency response procedure designed to quickly and effectively release railroad tank car internal vapor pressure and liquid products to avoid disastrous, uncontrolled tank rupture and environmental contamination. During derailment accidents, tank cars may become structurally compromised by denting, crack initiation, or puncturing, and/or subject to external heating and associated increase in internal pressure. The Vent and Burn procedure is applied to damaged tank cars only when all other emergency product removal methods have been considered and rejected, and the consequences of not relieving the internal tank car pressure are determined to be greater than using this procedure.

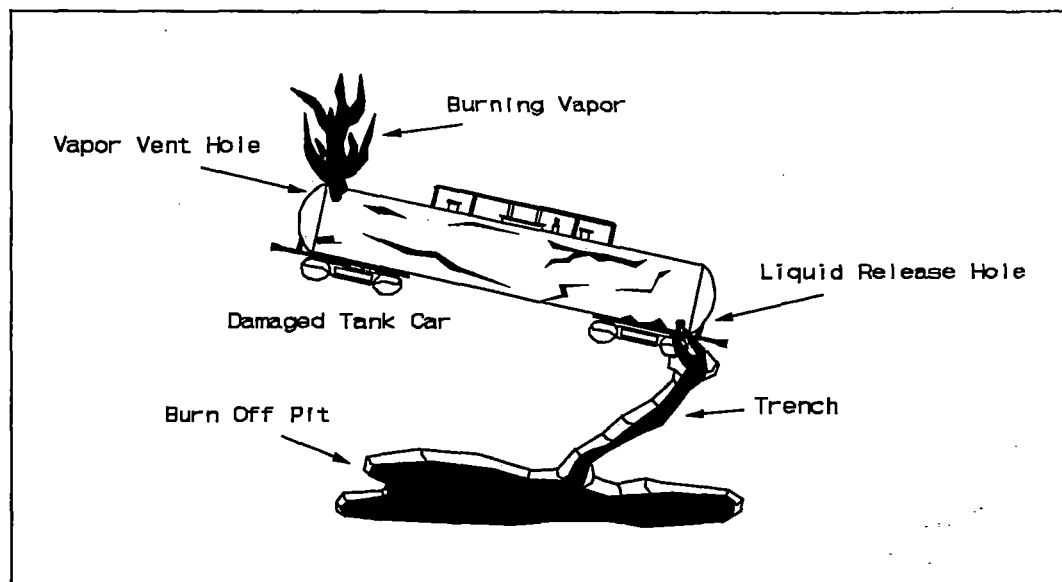
The Vent and Burn procedure involves the use of two explosive charges to cut holes in the tank car. The first charge is placed at the highest point of the tank car, over the product vapor space. Its detonation relieves the tank's internal vapor pressure. A second charge is placed at the lowest point of the liquid space to allow drainage of the product into a containment pit, where it is burned in a controlled setting, both neutralizing its environmental hazard and removing the potential for uncontrolled explosion. Figure 1 depicts the application of two explosive charges on a tank car. Figure 2 portrays Vent and Burn in progress.



**Figure 1. Schematic of Tank Car Displaying Vapor and Liquid Spaces; Recommended Application Points of Explosives Indicated**

## OVERVIEW (continued)

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**Figure 2. Application of Vent and Burn Procedure on Flammable or Combustible Liquid**

During preparation for Vent and Burn, it may be necessary to cut the tank car's protective jacketing and remove insulation or thermal protective coverings. This may require two or more additional explosive charges.

There are inherent risks associated with this procedure: the tank car tank could fail during the Vent and Burn due to undetected flaws; there is no way to control the flow of product once the explosive cut is made; and more than one entry to the accident scene may be required for the application of explosives.

## **REASONS FOR SELECTING THE VENT AND BURN METHOD**

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The Vent and Burn method may be used when the following conditions exist:

- The tank car tank has been exposed to fire resulting in elevated internal pressure and possible tank damage.
- The tank car body has been structurally weakened to an extent that it cannot be safely rerailed and moved to an appropriate unloading point.
- Site conditions prevent the use of cranes or other rerailing equipment.
- Conditions do not allow the safe transfer, venting or flaring of the tank car.
- Damage to leaking valves and fittings cannot be repaired.

## **PREFERRED CONDITIONS**

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To the extent possible, the following conditions should exist, or be met, before using the Vent and Burn method. These conditions are considered optimal, but do not have to be met in all cases. Each incident is unique.

- Nearby cars containing hazardous materials will not be affected adversely by the operation.
- Suitable Vent and Burn equipment is available.
- Personnel experienced with the Vent and Burn method are available.
- Appropriate precautions can be taken to protect people and property in the event of an accidental detonation during the Vent and Burn application.
- Adequate collection area is available for the burning operation.
- Cryogenic tank cars should not be considered due to the physical state of the products and the construction of the car itself.

## INHERENT RISKS

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As with many emergency response procedures, there are inherent risks associated with Vent and Burn. Due to the inherent risks involved with this procedure, it must be used only as a *last resort*, after all other methods of field product removal have been considered and rejected. Risks inherent to Vent and Burn include, but are not limited to, the following:

- Catastrophic failure of the tank is possible due to the improper application of explosives or undetected flaws in the tank. This could result in injury to emergency response personnel, exposure of the public to the product, or damage to property and the environment.
- Multiple entries into the accident site may be necessary to apply explosives, increasing the risk to the explosives technician.
- Upon initiation of the vent hole charge, the drain hole charge may be dislodged from the tank car, requiring another site entry for re-application of the charge.
- Product flow cannot be controlled after breaching the tank.

## CANDIDATE PRODUCTS

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The Vent and Burn procedure is limited in candidate products. This procedure should be discussed with the product manufacturer for full determination of this procedure's applicability. This procedure should not be used on products that may detonate or react in some other adverse way when exposed to air.

- The product may be a flammable compressed gas such as propane, butane, or butadiene.
- The product may be a flammable or combustible liquid such as alcohols, petroleum products, esters, or ketones.
- The product may be subject to polymerization, such as acrylates, and shipped with inhibitors which can be lost in a fire situation.
- The product must have sufficient flammability characteristics to allow the material to burn.
- Products with secondary hazards of Poison-Inhalation Hazard should not be considered.
- Corrosives, oxidizers, or poisonous liquids would require evaluation on an individual basis.
- Vent and Burn may release potentially harmful by-products of thermal oxidation.

## CANDIDATE TANK CARS

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The types of tank cars carrying candidate materials for Vent and Burn are classified as pressure and general service tank cars.

### PRESSURE CARS

Pressure tank cars are constructed of high tensile steels at least 9/16 inch thick. Typical cars carrying liquefied petroleum gases are 11/16 to 25/32 inch thick. These cars can be equipped with combinations of thermal protection, insulation, and a protective steel jacket. Tank cars carrying flammable gases are required to have protective head shields such as the type shown in Figure 3. These shields cover part or all of the tank head and restrict access to the tank shell during Vent and Burn.

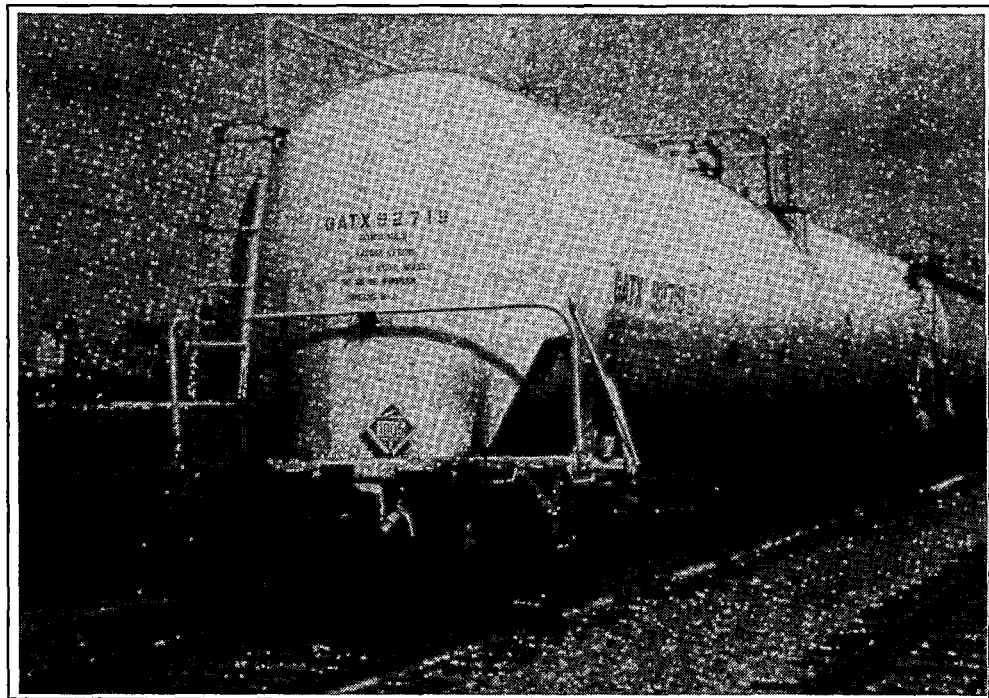


Figure 3. Trapezoidal Head Shield on Tank Car

## CANDIDATE TANK CARS (continued)

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DOT/TC 112/114 T -- These cars are thermally protected by a sprayed, brushed or troweled-on material approximately 1/8 inch thick. It has a stucco-like appearance. Head shields on the 112/114 T will be readily visible on each end of the car.

DOT/TC 112/114 J -- The "J" indicates the car has a 1/8-inch mild steel jacket. Its purpose is to hold a 1- to 2-inch-thick blanket-type ceramic fiber thermal protector in place against the tank shell. The jacketing and thermal protection must be removed to allow the final cutting charge to be placed on the tank shell surface. J cars require a minimum of two accident site entries for charge placement. Head shields on jacketed cars may not be readily visible, because they can be hidden behind the jacket.

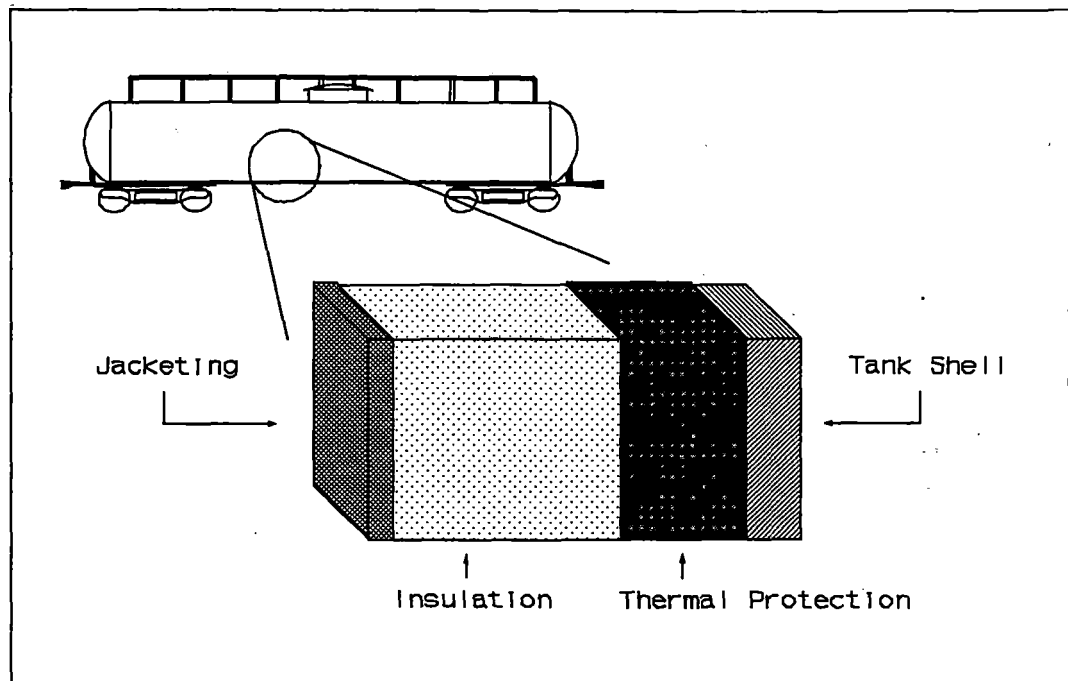
DOT/TC 105 J -- All 105 tank cars have 1/8-inch jackets covering 2 to 4 inches of insulation. If the car is a J, it will also have the ceramic fiber blanket thermal protection, 1 to 2 inches thick. The jacket, insulation, and thermal protection must be removed before placing the final cutting charges on a 105 tank car. Head shields, if installed, can be hidden by the jacket material.



## CANDIDATE TANK CARS (continued)

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Figure 4 displays the layers of jacketing, insulation, and thermal protection that may be present on candidate tank cars.



**Figure 4. Typical Layers of Jacketing, Insulation, Thermal Protection, and Tank Shell Seen on Tank Car**

## CANDIDATE TANK CARS (continued)

---

### GENERAL SERVICE CARS

General service tank car tanks are constructed of high tensile steels at least 7/16 inch thick. As with the pressure cars, the cars may be equipped with combinations of thermal protection, insulation, and a protective steel jacket. Head shields may be installed on some general service tank cars. Some general service cars are equipped with heater pipes. If the car has heater pipes, it may be difficult to place the final cutting charge on the liquid space of the car.

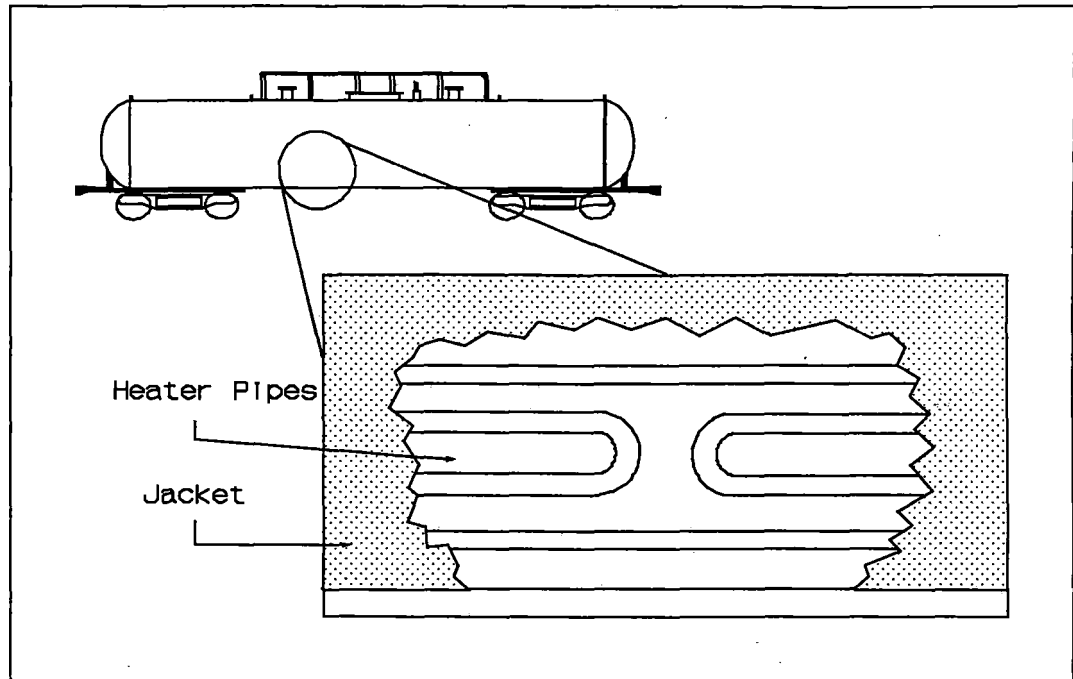
DOT/TC 111 A, AAR 211 A -- General service cars carrying flammable or combustible liquids may or may not be jacketed and insulated. If the car is jacketed, the jacket and insulating material must be removed to place the final cutting charges directly on the tank surface.

DOT/TC 111 J -- The "J" general service cars have the same features as the 112/114 J; they have head shields and jacketed thermal protection. The jacket and thermal protection must be removed.

## CANDIDATE TANK CARS (continued)

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Figure 5 displays the heater pipes that may be present on candidate tank cars. Multiple or non-circular tank car cutting charges may be used to maneuver around such heater pipes.



**Figure 5. Heater Pipes Located Beneath Jacketing on Some Candidate Tank Cars**

## **SAFETY PRECAUTIONS**

---

The following safety precautions should be taken when performing the Vent and Burn procedure:

<b>PRECAUTION</b>	<b>NOTES</b>
<ul style="list-style-type: none"><li data-bbox="237 555 938 676">■ Prepare a written plan of operation to ensure all parties involved have a clear understanding of the impending actions.</li><li data-bbox="237 725 938 846">■ Conduct briefings with all parties involved at each stage of the process to ensure mutual understanding.</li><li data-bbox="237 895 938 966">■ Use the appropriate personal protective equipment.</li><li data-bbox="237 1015 938 1051">■ Limit site access to required personnel only.</li><li data-bbox="237 1100 938 1200">■ Evacuate area based on wind conditions and the recommendations of the product manufacturer.</li><li data-bbox="237 1257 938 1370">■ Request Federal Aviation Administration to restrict air traffic over the site and the plume area.</li></ul>	

## SAFETY PRECAUTIONS (continued)

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PRECAUTION (continued)	NOTES
<ul style="list-style-type: none"><li>■ Establish perimeter monitoring for the product and any potential by-products of reaction with air.</li><li>■ Ensure adequate fire suppression resources are on hand.</li><li>■ Muster personnel and equipment into the staging area.</li><li>■ Use only a qualified explosives expert and the correct explosives.</li><li>■ Eliminate all ignition sources from the site.</li><li>■ Eliminate radio transmissions near the explosives.</li><li>■ Ensure all equipment is explosion-proof and intrinsically safe.</li></ul>	

## REQUIRED EQUIPMENT

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### TOOLS AND SUPPLIES

### NOTES

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- A minimum of two metal or hard plastic rings for holding the explosive in a circular shape. Recommend 2-inch-high material formed in a 9 3/8-inch diameter. Steel banding material is ideal.
- Epoxy adhesive to assist in holding the explosive on the tank. Must be compatible with polystyrene foam and site weather conditions.
- Fuses or other means to ignite the material as it flows from the tank.
- Incendiary grenade capable of remote operation.
- Combustible gas indicator and/or product-specific monitoring device for the product/by-products involved.
- A minimum of five sets of two-conductor, insulated wire, 16 gage or better, long enough to span from the explosive charges on the tank car to the detonator placed at a safe distance from the tank. Recommended length is 1/2 mile.

## REQUIRED EQUIPMENT (continued)

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### TOOLS AND SUPPLIES (continued)

### NOTES

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- Excavating equipment to dig burn pit, stabilize car(s), or to build earthen berms to shield car(s) from excessive heat.
- Shovels and other hand tools, as may be needed.
- Putty knives, chisels, hammers and wire brush to remove the sprayed-on thermal protection from a "T" car.
- Appropriate explosive charges as defined in the following section.
- Electronic detonator for the explosive charges.

## EXPLOSIVE CHARGES

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Explosives must be handled and applied by a qualified explosives expert with the proper permits. In order to obtain, transport, and use explosives, one is required to undergo a background check, pass hazardous materials transportation tests, obtain a commercial driver's license, and pass an explosives use test. A permit must then be obtained indicating these tasks have been completed satisfactorily.

As mentioned earlier in this document, it would be advisable to locate an explosives expert and discuss the Vent and Burn procedure before the actual need arises. The explosives expert will know how to use the charges, but may have no knowledge of tank cars.

Time is a factor in this product removal method. The location and travel time for the explosive expert must be considered in this process. It is suggested that the explosives expert be within approximately 8 hours of the site. When developing the plan, it may be desirable to have several qualified explosives experts to call upon.

A flexible, shaped explosive charge is recommended to cut the candidate tank car. A shaped charge can accurately cut along the perimeter of the desired hole, much as an oxy-acetylene torch. This is opposed to a bulk charge that will try to cut all of the metal in the center of the desired hole with brute force. A shaped charge uses less explosive material and reduces personnel risk during charge handling. It also reduces the risk of catastrophic tank failure during charge detonation.

A shaped charge orients its explosive material in a specific geometry to focus the detonation forces. Upon charge initiation, a jet of hot vapors is formed which cuts through the target material like a cutting torch.



## EXPLOSIVE CHARGES (continued)

EXPLOSIVES	NOTES
<ul style="list-style-type: none"><li data-bbox="232 391 865 512">■ A minimum of one explosive charge is required to cut the vent hole and release internal vapor pressure.</li><li data-bbox="232 555 921 676">■ A minimum of one explosive charge is required to cut the liquid hole and drain the tank.</li><li data-bbox="232 719 931 925">■ If the candidate tank car has a metal jacket, a minimum of two additional explosive charges is required -- one to cut the jacketing over the desire vent hole, and one to cut the jacketing over the liquid drain hole location.</li><li data-bbox="232 968 921 1089">■ A minimum of two blasting caps is required for each of the vapor vent and liquid drain charges. Use Number 6 or stronger caps.</li><li data-bbox="232 1132 943 1253">■ A minimum of one blasting cap is required for each jacket cutting charge. Use Number 6 or stronger caps.</li></ul>	

## EXPLOSIVE CHARGES (continued)

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The size of the vapor and liquid release holes has been estimated to vent and drain the tank in a relatively short period of time, reducing the risk of tank failure due to vapor expansion. An exit hole area is recommended and should be used whenever possible. As mentioned earlier, multiple or non-circular holes that add to the specified area may be used to maneuver around heater pipes or other equipment. Circular holes are strongly recommended, however, to avoid stress concentrations that may weaken and compromise the tank at the hole corners. When the tank jacket must be removed, the jacket should be cut to provide a minimum of 10 inches work space on all sides of the desired release hole.

Table 1 lists the appropriate type of explosive charge and release hole areas recommended. Do not use less than the suggested charge strengths. Charge strengths are listed by explosive material weight in grains (7000 grains = 1 pound) per running foot of manufactured charge. This unit is abbreviated as "gr/ft."

**Table 1. Recommended Charge Material, Strengths, and Sizing**

Target Material	Type of Charge	Desired Hole Area	Length of Charge
1/8-inch Jacket	300 gr/ft, foam-sheathed flexible shaped charge	255 sq.inches or 18 inches diam.	56 inches for a circular cut
Tank Barrel	5,400 gr/ft, foam-sheathed flexible shaped charge	38.5 sq.inches or 7 inches diam.	24 inches for a circular cut

The recommended explosive material is a mixture of Cyclonite (cyclo-1,3,5-trimethylene-2,4,6-trinitramine), Trimethyltrinitramine, and Hexagene, commonly called RDX. This material was used during field testing to successfully cut full scale tank cars.

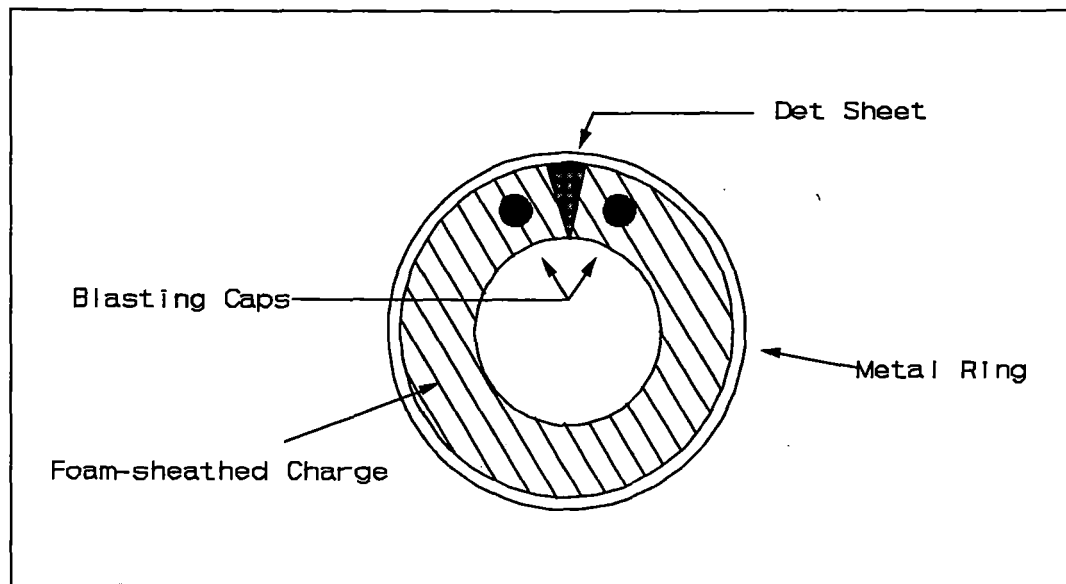
## EXPLOSIVE CHARGES (continued)

The 5,400 gr/ft foam-sheathed charge is recommended for tank shell thicknesses up to 25/32 inches. If the candidate tank is thicker than this, an explosives manufacturer will have to be contacted for a recommended charge. Currently 5,400 gr/ft is the strongest flexible foam-sheathed charge manufactured.

The explosive charges should be formed into a circular shape for application on the tank car. The metal or plastic retaining rings are used with the 5,400 gr/ft charges to help hold this shape. The lighter jacket charges can be applied and held in position with tape.

Detonation sheet is a material used in the fabrication of explosive charges to assure continuous and successful detonation. Sufficient detonation sheet must be procured to fill gaps formed at charge ends when the charge is bent into a closed circle.

Figure 6 displays the desired final charge construction, complete with retaining ring, detonation sheet, and charge initiating blasting caps.

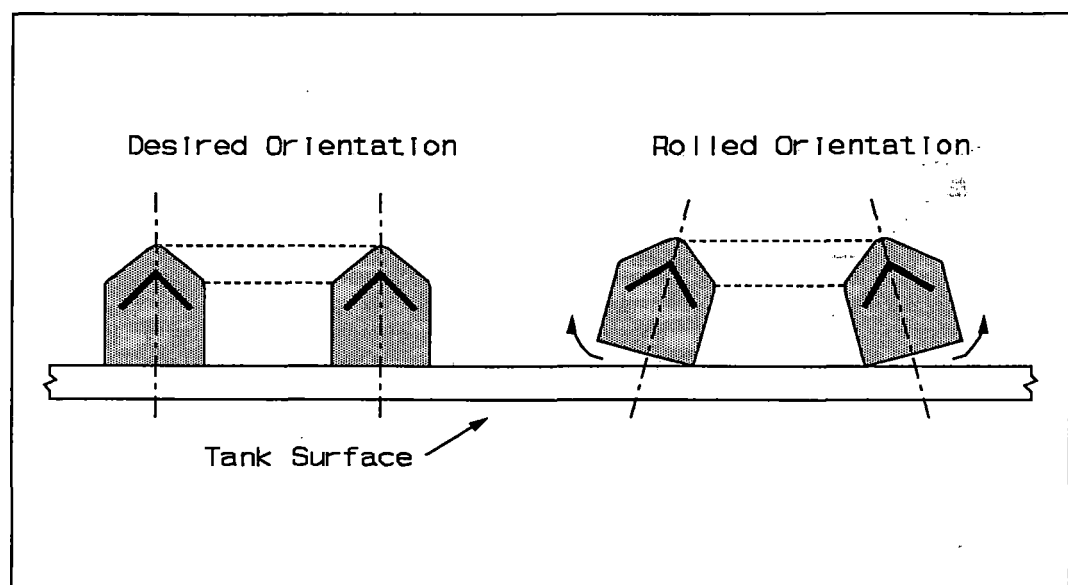


**Figure 6. Construction of Tank Cutting Charge with Detonation Sheet, Retaining Ring, and Blasting Caps**

## EXPLOSIVE CHARGES (continued)

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During Vent and Burn procedure development testing, charge construction and charge orientation relative to the tank car surface were seen to be critical to the success of charge cutting. A metal or plastic retaining ring was seen to be helpful in holding the charge ends together to allow a continuous cut of the tank car material. The ring also prevented the explosive charge from rolling away from the tank surface; such rolling allows the explosive cutting jet to strike the tank surface at a glancing angle and reduces its ability to cut the tank material. Figure 7 displays the desired charge orientation and the undesired rolled orientation.



**Figure 7. Desired and Rolled Orientations of Tank Cutting Charge**

Appendix A lists known manufacturers of the flexible foam-sheathed charge, including brand names. Appendix A also lists resources available to help find an explosives expert near the accident site.

## GENERAL PROCEDURES

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### PREPARATION FOR VENT AND BURN

### NOTES

- Prepare a Site Safety Plan.
- Post the Site Safety Plan in a conspicuous place for review by all parties involved.
- Monitor area for combustible atmosphere.
- Stabilize or remove surrounding railcars.
- Examine all other methods of field product removal to determine if the Vent and Burn method is the only practical alternative.
- Determine type of soil. Order clay for liner, if necessary, to prevent product leaching into the ground.
- Obtain required tools and equipment including excavation equipment, explosive material, explosives expert, and necessary permits.

## GENERAL PROCEDURES (continued)

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### PIT CONSTRUCTION

### NOTES

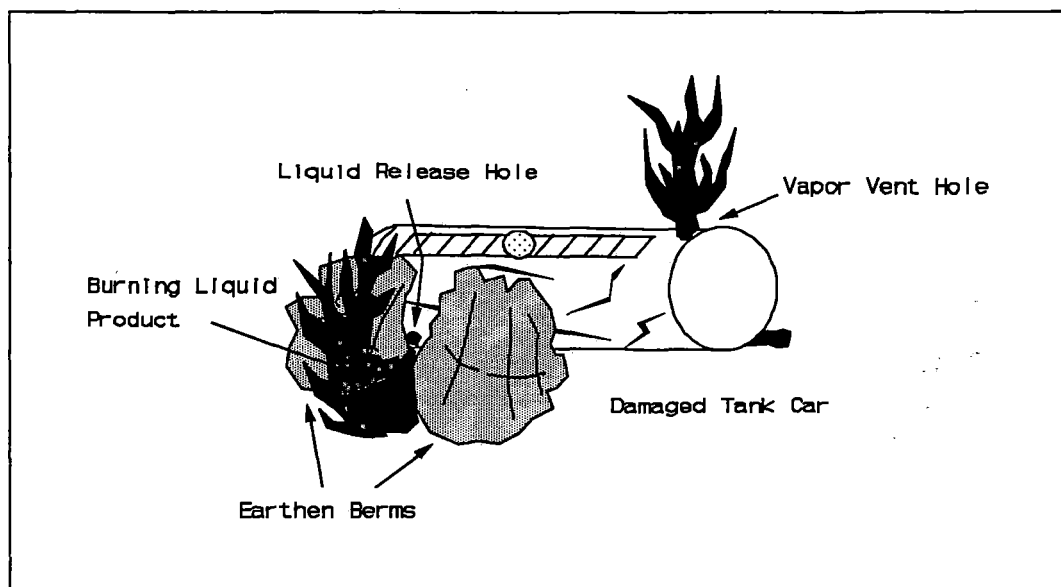
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- Determine water capacity of the tank car in gallons. This number is stenciled on the ends of the tank.
  
- Determine the size of the containment pit for the released product. (One cubic foot will contain approximately 7.5 gallons of liquid)
  
- Select the burn pit site.
  - The pit must be next to the target car if the lading is a compressed gas. The liquid product will boil when in contact with the low pressure of the atmosphere; it will not remain liquid long enough to reach a distant containment pit. Instead, a vapor cloud will form and burn near the tank surface. Shielding the tank from heat with earthen berms near the drain hole is recommended.
  - If the material is a flammable or combustible liquid, the pit should be placed about 200 to 250 feet from the tank car, if possible, to disperse the heat of product burning. A trench must be dug to direct the liquid product to the burn pit. Flames will flash back over the surface of the trench, however. Use earthen berms near the liquid drain hole to shield the tank from heat.

## GENERAL PROCEDURES (continued)

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Figure 1 had displayed Vent and Burn performed on a flammable or combustible liquid. Figure 8 depicts Vent and Burn performed with a compressed gas product.



**Figure 8. Vent and Burn Performed with Compressed Gas -- Pit Near Tank Car**

## GENERAL PROCEDURES (continued)

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### PIT CONSTRUCTION (continued)

### NOTES

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- Design the pit depth based on the product to be discharged. The greater the surface area exposed to fire, the quicker the material will be consumed, thus reducing permeation into the soil. Use a clay liner if necessary.
- Excavate the pit to the pre-determined size.
- Clear all vegetation and debris from the pit area about 100 feet in all directions and about 30 feet on each side along the trench, as the fire will flash back along the trench.



## GENERAL PROCEDURES (continued)

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### SITE PREPARATION

### NOTES

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- Establish a safe area for detonating the charge approximately 1/2 mile from the car.
- Identify and establish primary and secondary escape routes. Do not establish an area that will be cut off from entry/exit when the burn pit is ignited.
- Clear the site of unauthorized personnel.
- Establish radio silence before bringing explosives into the area. Alternate communications such as voice or hand signals should be used from this point until after detonation of charges.
- Lay wires to be used for detonation and shunt them. Shunting is accomplished by twisting the ends of the wires together. Make sure the wires reach from the tank car to the safe zone. At least two sets of wires are required -- one for the vapor vent hole and one for the liquid drain hole. If jacketing must be removed, two more sets of wires are recommended. A fifth set of wires is required for remote incendiary grenade detonation. Try to use different colors of wire to avoid confusion.
- Check the wires for continuity with appropriate instrument.

## GENERAL PROCEDURES (continued)

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### SITE PREPARATION (continued)

### NOTES

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- Select the vapor space and liquid drain target areas on the tank. Use the area toward the ends of the car; the car center has fittings and education pipes that may interfere with cutting. Do not plan tank cutting in the region under head shields.
- If the candidate tank car has a jacket, this covering must be removed to allow access to the tank surface. See the Removing Tank Jacket section on page 26.
- If the candidate tank car has sprayed-on thermal protection, remove it at the desired charge placement locations. Use the putty knives, chisels, and hammers. A wire brush may help clean the tank surface.
- It is never recommended to cut through the head shield to gain access to the tank shell. Such cutting may damage the tank shell and result in catastrophic tank failure. Burning product will be held against the tank shell. If the head shield must be cut, use 56 inches of 5,400 gr/ft foam-sheathed charge and follow the Removing Tank Jacket procedure on page 26.

## GENERAL PROCEDURES (continued)

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### REMOVING TANK JACKET

### NOTES

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- Establish radio silence before handling explosive charges.
- Prepare two 56-inch-long pieces of the 300 gr/ft flexible charge to remove the jacket and insulating material covering the target locations for both the vapor and liquid space. Be sure to overlap the ends of the charge. Do not place the charge on the head of the car if the car has head shields.
- The diameter of the jacket material to be removed must be about twice the diameter of the final cut in the car shell.
- Attach the explosive charges to the jacket material with tape or an epoxy compound. Weather or surface conditions may hamper charge attachment. The charge must contact the tank surface in a uniform manner all the way along its length. Do not allow the charge to raise off the surface.
- Place a blasting cap into each explosive and connect the detonator lead wires to the caps. Both jacket cutting charges may be prepared and detonated at the same time.

## GENERAL PROCEDURES (continued)

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### REMOVING TANK JACKET (continued)

### NOTES

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- Give everyone involved a 10-minute warning prior to jacket charge detonation.
- After confirming all safety factors are in effect, connect the wires from the detonator to the power source and detonate the charges on the jacket.
- Re-shunt the wires leading to the blasting caps.
- After waiting about 30 seconds, check the site for any fires or other problems that may have been caused by the blast. Be aware of flying debris.
- Proceed to the car and check for any fire in the area where the jacket was removed.
- Using the proper protection, remove any remaining insulation/thermal protection where the cutting charge will be placed. The edges where the jacket was cut will be sharp and jagged. A wire brush may be required to remove remnants of adhesives from the tank surface.
- Check all areas for safety, and after assurances, proceed.

## GENERAL PROCEDURES (continued)

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### VENT AND DRAIN HOLES

### NOTES

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- Establish radio silence before handling explosive charges.
- Prepare two 24-inch-long sections of the 5,400 gr/ft charges for placement on the tank for cutting the vapor and liquid holes. The retaining rings will be required to maintain the circular shape desired on the car. Apply detonation sheet or other booster to the charge ends. Prepare the charges with as little gap at the charge ends as possible.
- Establish a remote incendiary device to ignite the pit, if necessary. (This will use the fifth set of lead wires.) Place fusee near vapor vent hole if vapor burning is desired.
- Apply the charges to the vapor and drain hole areas of the car. Epoxy adhesive and tape are recommended to attach the charge to the tank surface. Weather and surface conditions may interfere. It is crucial to achieve a uniform spacing of the charge from the tank surface. Do not allow the charge to roll or pull away from the tank surface. External bracing, such as wood, may be required to hold the charge in place.

## GENERAL PROCEDURES (continued)

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### VENT AND DRAIN HOLES (continued)

### NOTES

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- Place at least two blasting caps into each of the charges. Attach the blasting cap wires to the detonator lead wires.
- Prepare both vent and liquid charges before proceeding. Entry into the accident scene will be extremely dangerous after detonation of the vent charge.
- Give everyone involved a 10-minute warning prior to vapor vent hole detonation. Light vapor fusees and return to safe zone.
- Attach lead wires from vapor vent charge to power source. Detonate the vapor vent charge. Re-shunt wires after detonation.
- Check site for fires or other problems.
- Venting time will vary depending on product from a few seconds to a few hours. A decrease in vapor flare size or vent noise is expected over time.
- The vapor venting should be allowed to complete before detonation of the liquid drain hole. However, if conditions demand quicker product release, the liquid charge may be detonated at any time after the cutting of the vent hole.

## GENERAL PROCEDURES (continued)

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### VENT AND DRAIN HOLES (continued)

### NOTES

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- Give everyone involved a 10-minute warning prior to liquid drain hole detonation. Return to the safe area.
- Ignite the burn pit using the remote device.
- Attach the leads from the liquid drain charge to the power source and detonate this charge. Re-shunt wires after detonation.
- Drain activity should take between 15 and 35 minutes for a tank car in the horizontal position, depending on tank capacity. Inclined tank cars will drain up to twice as fast. A decrease in drain rate and fire ball size is expected over time. Total product burning should be completed in about 2 hours.
- Observe accident site and surrounding areas for dangers resulting from the Vent and Burn procedure.

## SHUT DOWN THE VENT AND BURN OPERATION

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When the burning is completed, perform the following steps.

TASK	NOTE
<ul style="list-style-type: none"><li data-bbox="233 470 932 544">■ Examine the tank to ensure all product has been drained.</li><li data-bbox="233 591 932 666">■ Purge all remaining vapors using an inert gas compatible with the last contents of the car.</li><li data-bbox="233 712 932 832">■ Monitor tank and surrounding areas with a combustible gas indicator before allowing the tank to be moved.</li><li data-bbox="233 878 932 995">■ Remove the car from the accident scene and perform the required environmental remediation.</li></ul>	

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## PROBLEMS DURING VENT AND BURN

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Some problems may occur during the Vent and Burn procedure. If any of the following events happen, perform the corresponding action.

EVENT	ACTION
Charge does not detonate.	Wait at least 1 minute. Check wiring, replace caps, and attempt to refire.
Vent flare increases size or noise for a sustained period (longer than 10 to 15 seconds).	Clear the area and detonate liquid hole <u>immediately</u> . The heat added to the tank is expanding the product faster than the product can be vented.
Liquid drain rate increases for a sustained period (longer than 10 to 15 seconds).	Clear the area. The heat added to the tank is expanding the product faster than the product can be drained.

**APPENDIX A**  
**EXPLOSIVES RESOURCES**

## EXPLOSIVES MANUFACTURER

NAX (North American Explosives)  
Highway 175  
P.O. Box 160  
Graham, KY 42344  
Telephone: 502-338-1988  
FAX: 502-338-4910

## EXPLOSIVES

The materials found to work the best are manufactured by NAX and are called Explosive Cutting Tape™(ECT). Further information can be obtained by calling the telephone number listed above.

At the time of publication of this document, NAX is the sole supplier of the Explosive Cutting Tape. NAX should be able to supply a list of explosives distributors in the United States.

## EXPLOSIVES EXPERTS

Information concerning explosives experts may be obtained by calling the

Institute of the Makers of Explosives  
Telephone: 202-429-9280

**APPENDIX B**  
**LITERATURE SEARCH**

## LITERATURE SEARCH

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