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# Hardening Existing Strategic Special Nuclear Material Storage Facilities

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## ABSTRACT

This report provides guidelines to aid NRC licensees in evaluating existing strategic special nuclear material storage facilities, discusses typical tools that could be employed to penetrate such facilities, and provides simple and cost effective hardening techniques. The report was developed to provide guidance in support of the Physical Protection Upgrade Rule, effective March 25, 1980.

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## 1. INTRODUCTION

This report provides initial guidance to licensees in their efforts to meet the provisions of the Physical Protection Upgrade Rule for Fixed Sites, (10 CFR 73.20, 73.45, and 73.46). The reference system within the Physical Protection Upgrade Rule describes vaults used to protect SSNM as being capable of preventing entry by a single action in a forced entry attempt, except as such single action would both destroy the barrier and render contained SSNM incapable of being removed, and shall provide sufficient delay to prevent removal of stored SSNM prior to arrival of response personnel capable of neutralizing the design basis threat stated in § 73.1. It is recognized that existing licensee SSNM storage facilities are constructed of various materials and provide varying levels of security. Many licensees will have to address the question of how to meet these new requirements for SSNM storage vaults and what can be done to upgrade their present SSNM storage facility.

This document is a preliminary report on an NRC-sponsored study on Vault Design Guidance. It provides guidelines which aid licensees in evaluating existing SSNM storage facilities, discusses typical tools that could be employed to penetrate such facilities, and provides simple cost effective hardening techniques. The results of further validation testing of the hardening techniques contained

herein will be incorporated into a final report, at a future date.

The following limitations have been placed on the scope of this effort:

1. This report will address the physical barriers of existing SSNM storage facilities (i.e., walls, floor, roof, doors and various apertures);
2. This report will provide hardening techniques to increase penetration resistance of SSNM storage facilities against the threat of 10 CFR Part 73.1.

   (Scenarios involving the use of explosives in such quantities that SSNM in vaults is rendered unusable by the adversary are expressly excluded);
3. This report will not consider other physical barriers adjacent or close to the SSNM storage facilities;
4. This report will not consider health and safety or other environmental factors that will be of consideration to the licensee in the handling and storage of special nuclear material.

For the purposes of this report, an SSNM storage vault is defined as a windowless enclosure with walls, floor, roof, and door(s) designed and constructed to delay penetration from forced entry. Penetration resistance time is defined as the time required to make an approximately 18-inch entry opening into an SSNM storage vault structural component and includes preparation time such as setting up mechanical or power tools and/or placement of explosives.

## 2. GUIDELINES FOR SSNM STORAGE FACILITY EVALUATION

The NRC is interested in increasing the level of security provided by SSNM storage facilities in the licensed nuclear fuel cycle industry. The licensee, in determining if his SSNM storage facility meets the proposed upgraded level of security, must first evaluate his present structure. The report provides the following guidelines for accomplishing this task:

1. Examine the Existing Construction

   Using the Sandia Barrier Handbook, referenced in the Fixed Site Physical Protection Upgrade Rule Guidance Compendium, barrier penetration data provided in Appendix 5.1, or any other data on materials penetration such as Engineering Handbooks, etc., determine the penetration resistance of the material utilized in the walls, floor, roof, door(s), and other apertures. Consider the weakest part of each component, such as joints, casing, hinges, and locks.

2. Evaluate Existing Apertures

   Determine if utility ports or electrical, heating, ventilation, and air-conditioning ducts would allow entry into the vault. Determine if existing apertures are constructed such that, although preventing physical entry, would allow mechanical arms/grabbers to be used to remove material. (It should be noted that windows are not permitted in SSNM storage vaults in the Physical Protection Upgrade Rule.)

3. Evaluate the Location

   How accessible is the SSNM storage facility from outside the building? Determine if relocating the SSNM storage facility

closer to or away from existing walls would improve the penetration resistance.

4. Determine the Location of Electrical Power

   Electrical power should not be readily available to the adversary.

After the present SSNM storage facility is evaluated, list the components in order from the shortest to the longest penetration resistance time provided.

Compare this penetration resistance time to the time estimated for arrival of response personnel who are capable of neutralizing the design basis threat stated in 10 CFR Part 73.1. Identify the components whose penetration resistance time is less than the response force reaction time. These components become the vulnerable components of the existing SSNM storage facility that will require upgrading.

Once having identified the vulnerable components of his SSNM storage facility, the licensee should refer to Section 4 for upgrading guidance. Section 4 of the report, HARDENING TECHNIQUES, addresses typical components of SSNM storage facilities, evaluates a variety of structural material presently utilized in these components, and provides techniques for improving their penetration resistance.

## 3. PENETRATION TOOLS

Tools and materials that are considered available to the adversary in penetration operations include (1) hand tools, (2) power tools, (3) thermal tools, and (4) explosives. A brief description of the most commonly used tools, together with their relative effectiveness against barriers, is presented in Appendix 5.2. It can reasonably be expected that penetration attempts will mostly frequently use explosives or man-operated hand tools weighing less than 100 pounds. Consequently, only tools and materials in these categories are considered herein. Appendix 5.3 includes a list of penetration tools by category and associated weight. The licensee should also be aware, however, of the potential penetration tools he is providing at his facility. A forklift left unattended with ignition keys would provide a convenient penetration tool to an adversary.

## 4. HARDENING TECHNIQUES

The hardening techniques described in this section are provided as guidance for simple and cost effective ways of increasing the penetration resistance time of existing SSNM storage facility structural components. The application of these hardening techniques should be reviewed with the NRC prior to significant investment or adaptation since the physical characteristics and operational requirements may vary from site to site.

The design goal of these hardening concepts was to require the adversary to make more than one penetration attempt and to use more than one penetration tool. To accomplish this task, concepts such as using multiple barriers of different materials were employed. To minimize the effects from a single explosive charge, concepts were incorporated which provide space between barriers to dissipate blast effects, thus requiring more than one charge for multiple barriers. The concept of a suppressive shield, which breaks up the explosive shock wave and vents gases to minimize the energy applied to the solid portion of the structure, was also utilized where possible to minimize the effects from explosives. Approximately one inch of steel when used in a suppressive shield configuration is considered equal to a one foot reinforced concrete barrier with respect to minimizing the effects from blast and fragmentation. Concepts are also incorporated that deny initial access to such vulnerable components as door hinges, jambs and locks.

The information for each hardening technique is presented in two parts - data sheet and diagram. The data sheet describes the existing structural component and the time and tools required for penetration. Hardening action is then provided as step by step instructions utilizing simple and cost effective materials that in many cases could be fabricated in the licensee maintenance shop. Validation testing of all of the techniques presented has not been completed to date. Increased penetration resistance times provided have been estimated based on inputs from a variety of sources, including structural engineers, welders and demolitionists. A diagram showing the hardening technique applied to the existing structural component is provided to supplement the data sheet.

The hardening techniques are organized by specific structural components. Techniques 1 to 6 address walls and ceilings; Techniques 7 to 9, apertures; Techniques 10 and 11, doorways; Techniques 12 and 13, doors; and Techniques 14 to 16, door jambs, hinges, and locks.

Technique No. 1 - Hardening Chain Link Fence Wall

EXISTING STRUCTURE - Chain-link fabric supported by 3" diameter pipe.

TOOLS REQUIRED FOR PENETRATION - Boltcutter

PENETRATION TIME - 32 seconds

HARDENING ACTION -

1. Add to exterior of fence fabric 2"x4" studs on 18" centers.
2. Attach 2" thick rough cut oak wooden shield to studs thus providing 3½" space between the fence fabric and the wooden shield.
3. Attach ¼" ribbed, pierced steel planking to wooden shield.
4. Build an 8" solid concrete block wall directly against planking.

INCREASED PENETRATION RESISTANCE TIME - Approximately 15 minutes

INCREASED THICKNESS OF WALL - Approximately 16"

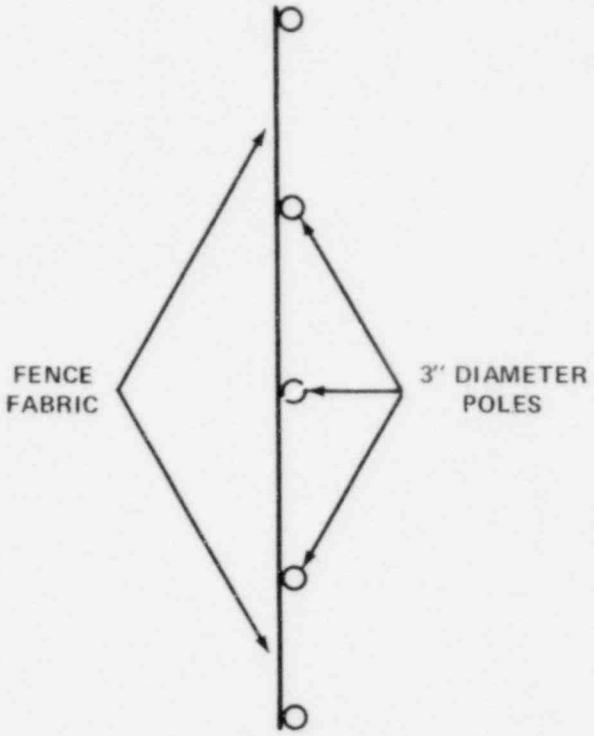
ADDITIONAL TOOLS REQUIRED - Boltcutter
Sledgehammer
Cutting torch
Saw
Explosives

ADVANTAGES OF TECHNIQUE -

1. Requires multiple penetrating tools
2. Requires multiple breaching explosive charges

DIAGRAM 1 – Hardening Chain Link Fence Wall

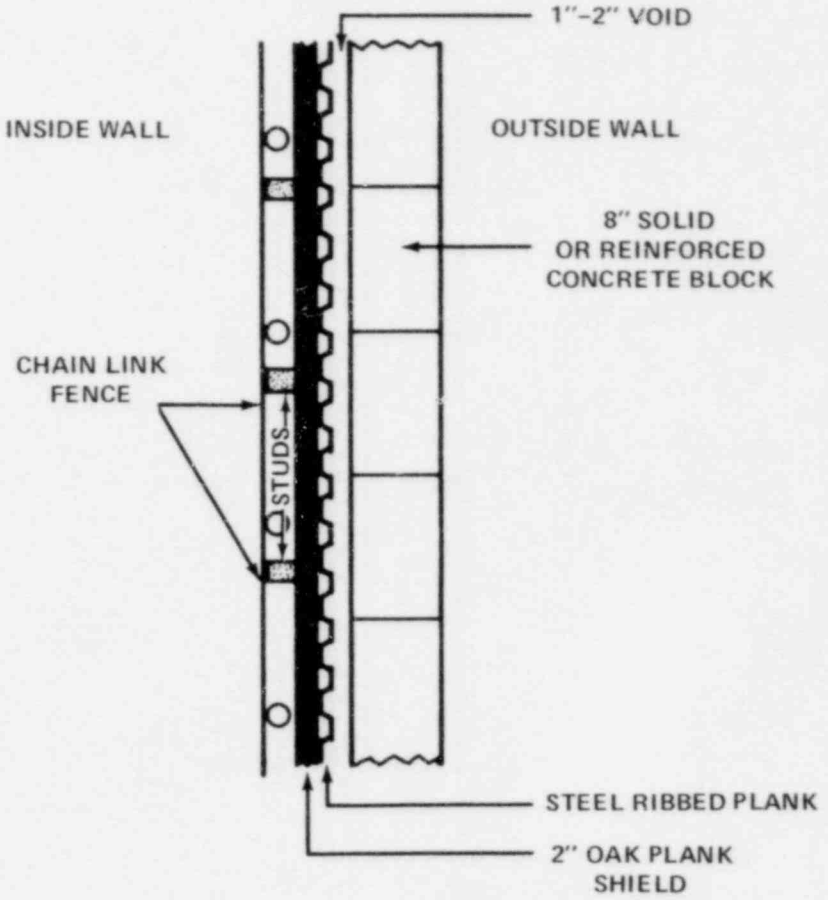
EXISTING STRUCTURE
TOP VIEW




PENETRATION RESISTANCE TIME

32 SECONDS

HARDENED STRUCTURE
TOP VIEW




PENETRATION RESISTANCE TIME

APPROXIMATELY 15 MINUTES

Technique No. 2 - Hardening Fiberboard or Plasterboard Wall

EXISTING STRUCTURE - Standard fiberboard or plasterboard wall

TOOLS REQUIRED FOR PENETRATION - Fire axe

PENETRATION TIME - 30 seconds

HARDENING ACTION -

1. Add to both sides of existing wall 3/4" to 1" thick good grade plywood panels.

2. Attach 2"x2" or 2"x4" good grade wood studs at 16" centers and at plywood panel seams with screw type nails.

3. Attach 3/4" to 1" thick good grade plywood panels to studs with panel seams offset from previously applied panel.

4. Attach expanded metal mesh type fabric of at least 3/16" thickness to plywood.

5. Add another layer of 2"x2" or 2"x4" good grade wood studs equidistant between studs added in step 2.

6. Add a layer of plywood similar to step 3.

INCREASED PENETRATION RESISTANCE TIME - Approximately 15 minutes

INCREASED THICKNESS OF WALL - Approximately 11"

ADDITIONAL TOOLS REQUIRED - Metal and wood saw, or combination blade

- Explosives

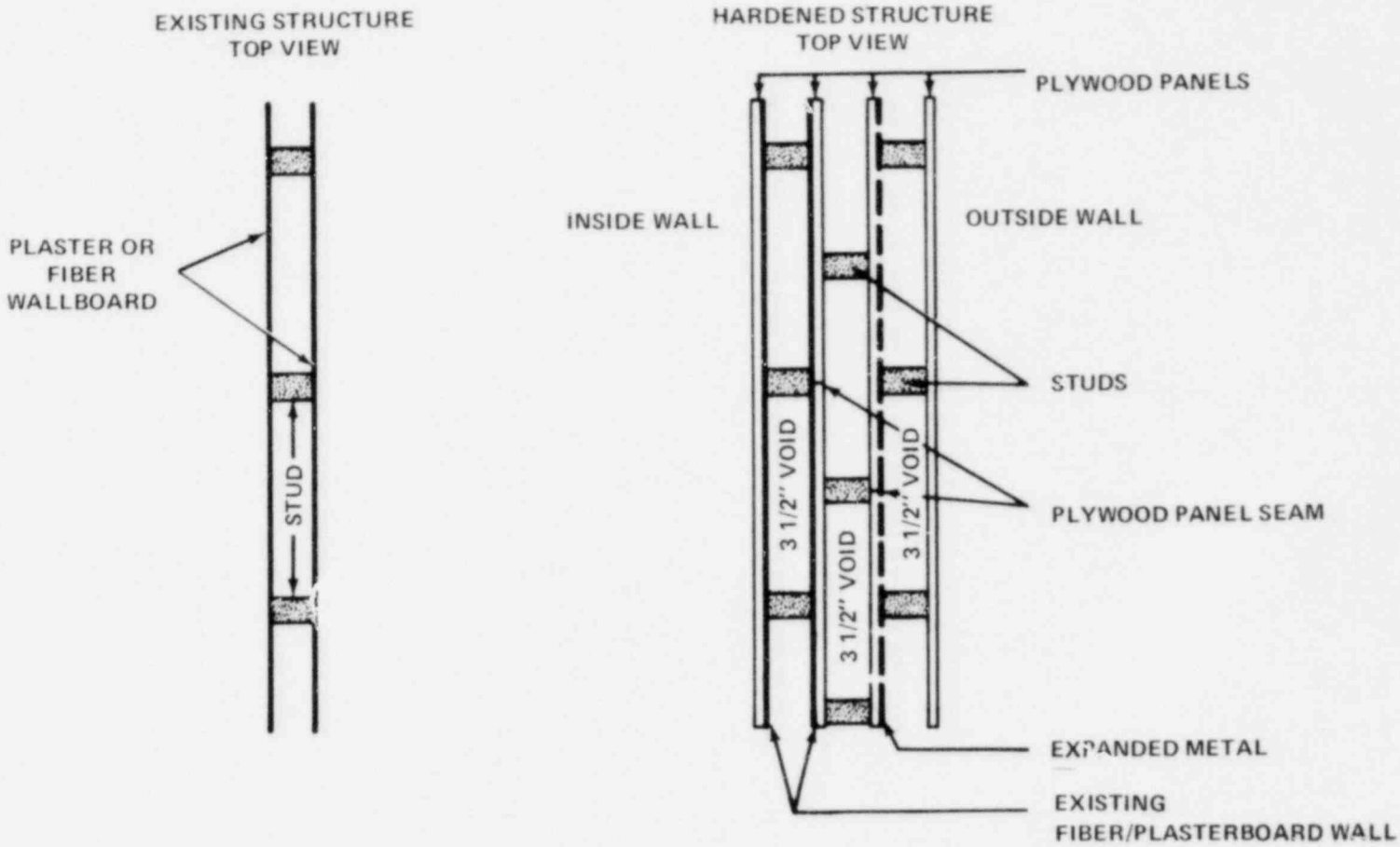
ADVANTAGES OF TECHNIQUE -

1. Multiple types of material require different types of saw blade or combination blade.

2. Void between panels increases thickness of wall forcing the use of a larger saw blade.

3. Void between panels vents and dissipates explosive gases and pressures requiring multiple charges.

DIAGRAM 2 – Hardening Fiberboard or Plasterboard Wall




PENETRATION RESISTANCE TIME

30 SECONDS

PENETRATION RESISTANCE TIME

APPROXIMATELY 15 MINUTES

Technique No. 3 - Hardening Hollow Concrete Block Wall

EXISTING STRUCTURE - 8" hollow, non-reinforced concrete block

TOOLS REQUIRED FOR PENETRATION - Sledgehammer

PENETRATION TIME - 1½ minutes

HARDENING ACTION -

1. Install 2" x 4" studs at 16" centers at least 2" from existing wall.

2. Attach two layers of 1" good grade plywood to studs.

3. Add layer of #5 or higher rebar grate with a minimum of 4" grid to plywood. Imbed grate into floor and ceiling and weld at intersections.

INCREASED PENETRATION RESISTANCE TIME - Approximately 10 - 15 minutes

INCREASED THICKNESS OF WALL - Approximately 8 inches.

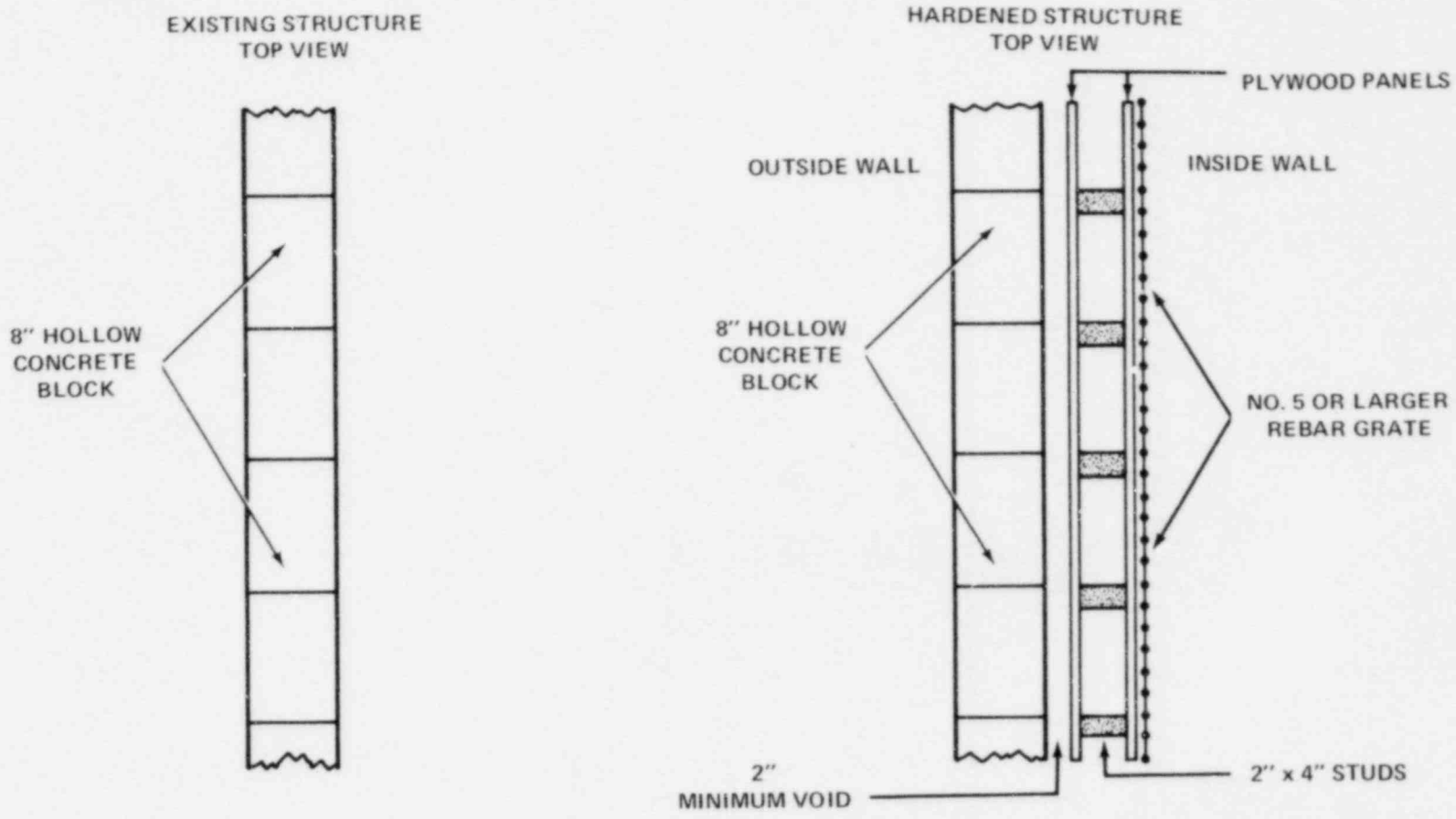
ADDITIONAL TOOLS REQUIRED - Saw
Hydraulic boltcutter
Explosives

ADVANTAGES OF TECHNIQUE -

1. Different penetration tools required

2. Requires considerable time to place separate explosive charges

DIAGRAM 3 – Hardening Hollow Concrete Block Wall




PENETRATION RESISTANCE TIME

1 1/2 MINUTES

PENETRATION RESISTANCE TIME

APPROXIMATELY 10–15 MINUTES

Technique No. 4 - Hardening Hollow or Reinforced Concrete Block Wall

EXISTING STRUCTURE - 8" hollow or reinforced concrete block.

TOOLS REQUIRED FOR PENETRATION - Sledgehammer
Boltcutters

PENETRATION TIME - 1½ minutes

HARDENING ACTION -

1. Layer tires on inside of vault wall.
2. Secure tires by inserted and interwoven grate of #5 or #6 rebar. Rebar should be welded at each intersection and penetrate through tire material.
3. Add layer of 2" solid oak plank or two 1" panels of 9 good grade plywood supported by 2"x 4" studs on 16" centers. If plank is used, it should be separated by the studs.

INCREASED PENETRATION RESISTANCE TIME - Greater than 30 minutes

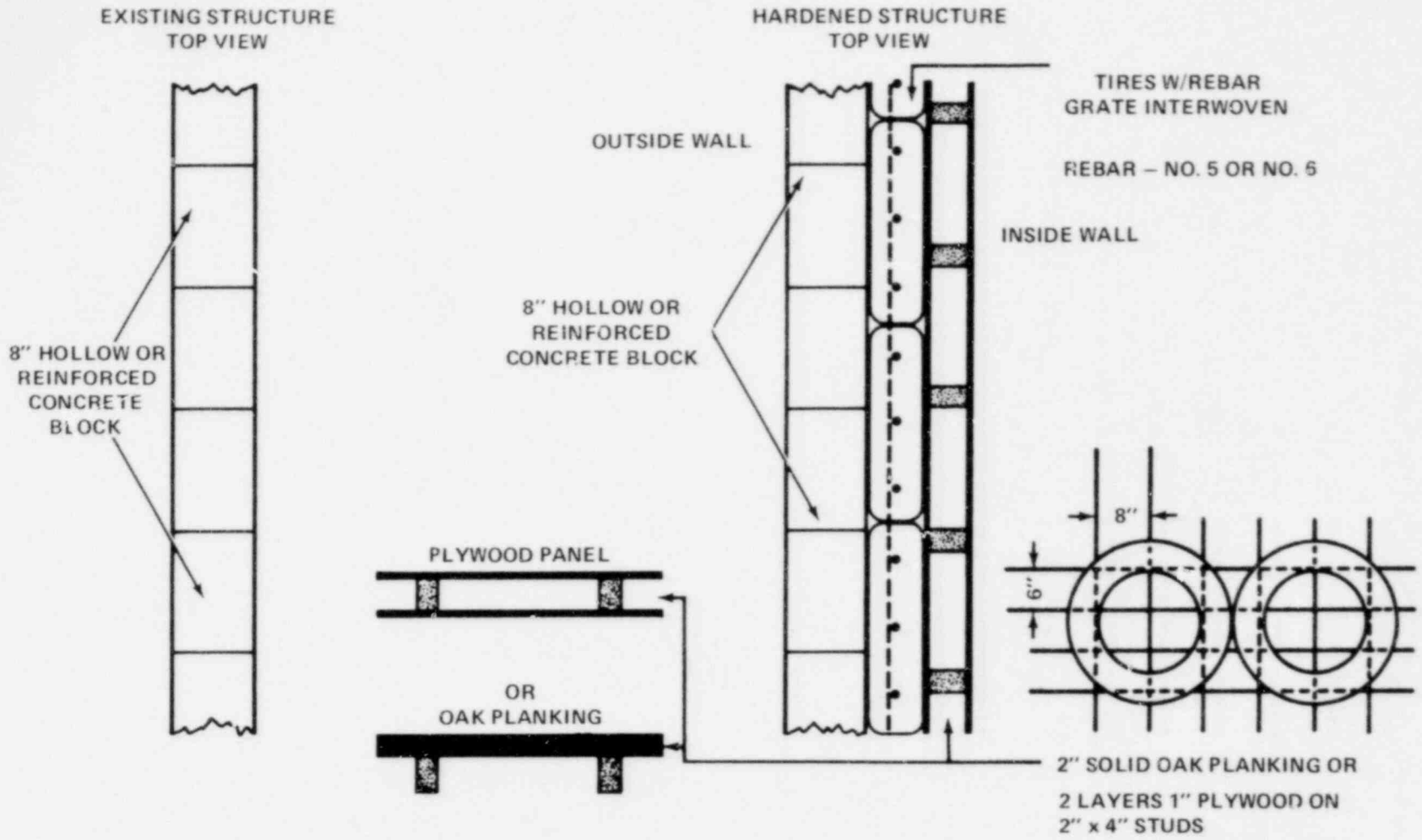
INCREASED THICKNESS OF WALL - Approximately 13 inches

ADDITIONAL TOOLS REQUIRED - Cutting torch
Saw
Explosives

ADVANTAGES OF TECHNIQUE -

1. Utilizes easily obtained material.
2. Tires help absorb explosive pressures.
3. Void around tires helps vent and dissipate explosive gases.
4. Different penetration tools required.
5. Tires delay access by thermal or mechanical cutting tools.

DIAGRAM 4 – Hardening Hollow or Reinforced Concrete Block Wall




PENETRATION RESISTANCE TIME

1 1/2 MINUTES

PENETRATION RESISTANCE TIME

GREATER THAN 30 MINUTES

Technique No. 5 - Hardening Any Type Wall or Ceiling

EXISTING STRUCTURE - Any type wall or ceiling

TOOLS REQUIRED FOR PENETRATION - Depends on existing wall or ceiling

PENETRATION TIME - Depends on existing wall or ceiling

HARDENING ACTION -

1. Anchor I-beam vertically in concrete base.
2. Interlock as many additional I-beams as necessary for length of wall.

INCREASED PENETRATION RESISTANCE TIME - Approximately 2-4 hours

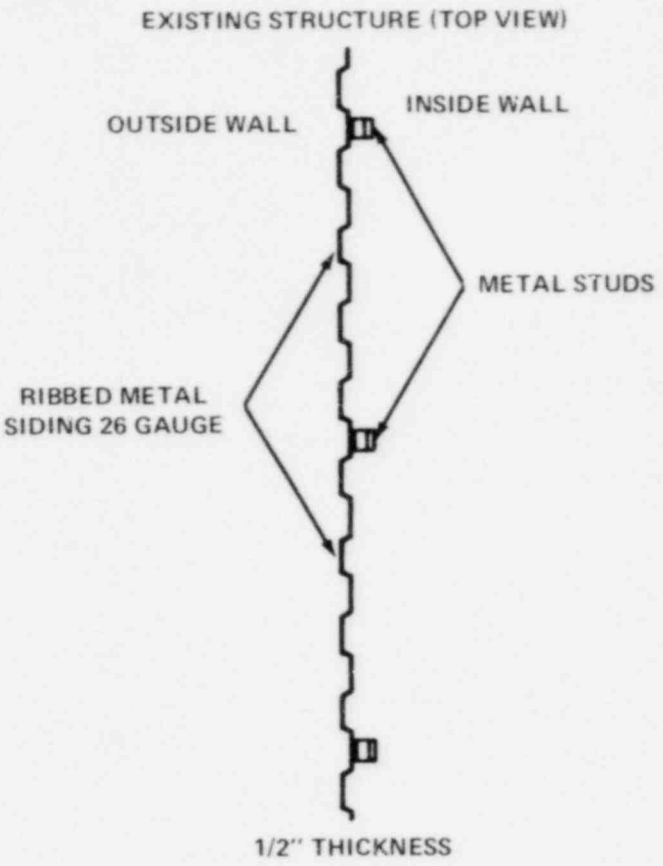
INCREASED THICKNESS OF WALL - Approximately 8 inches

ADDITIONAL TOOLS REQUIRED - Cutting torch (large unit)
Multiple explosive charges
Oxy-lance

ADVANTAGES OF TECHNIQUE -

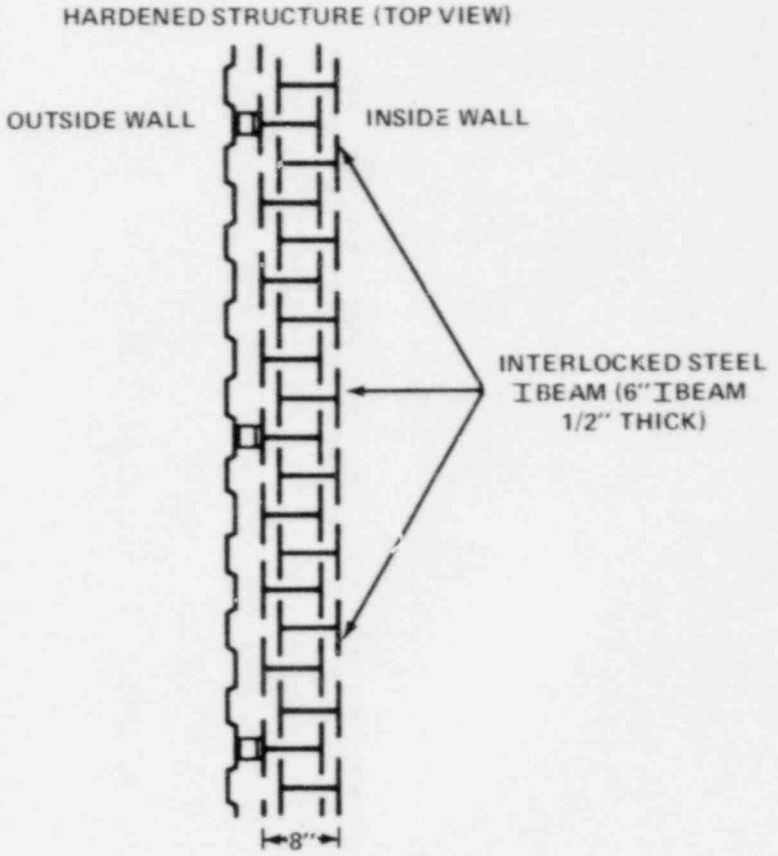
1. Utilizes principle of suppressive shielding.
2. Relatively easy to construct.
3. Can be used for roofs and ceilings as well as walls.

DIAGRAM 5 – Hardening Any Type Wall or Ceiling




PENETRATION RESISTANCE TIME

30 SECONDS




PENETRATION RESISTANCE TIME

APPROXIMATELY 2–4 HOURS

Technique No. 6 - Hardening Opening in Ceiling or Wall

EXISTING STRUCTURE - Opening in Ceiling or Wall

TOOLS REQUIRED FOR PENETRATION - Depends on existing opening

PENETRATION TIME - Depends on existing opening

HARDENING ACTION

1. Add strong steel jamb to opening

2. Form 3 separate grates by welding #4 rebar into 4" grids. Weld grates to inside center and outer lips of jamb. (Another method is to weld 6 separate layers of rebar alternating vertical and horizontal and off set from each other.)

INCREASED PENETRATION RESISTANCE TIME - Approximately 15 minutes

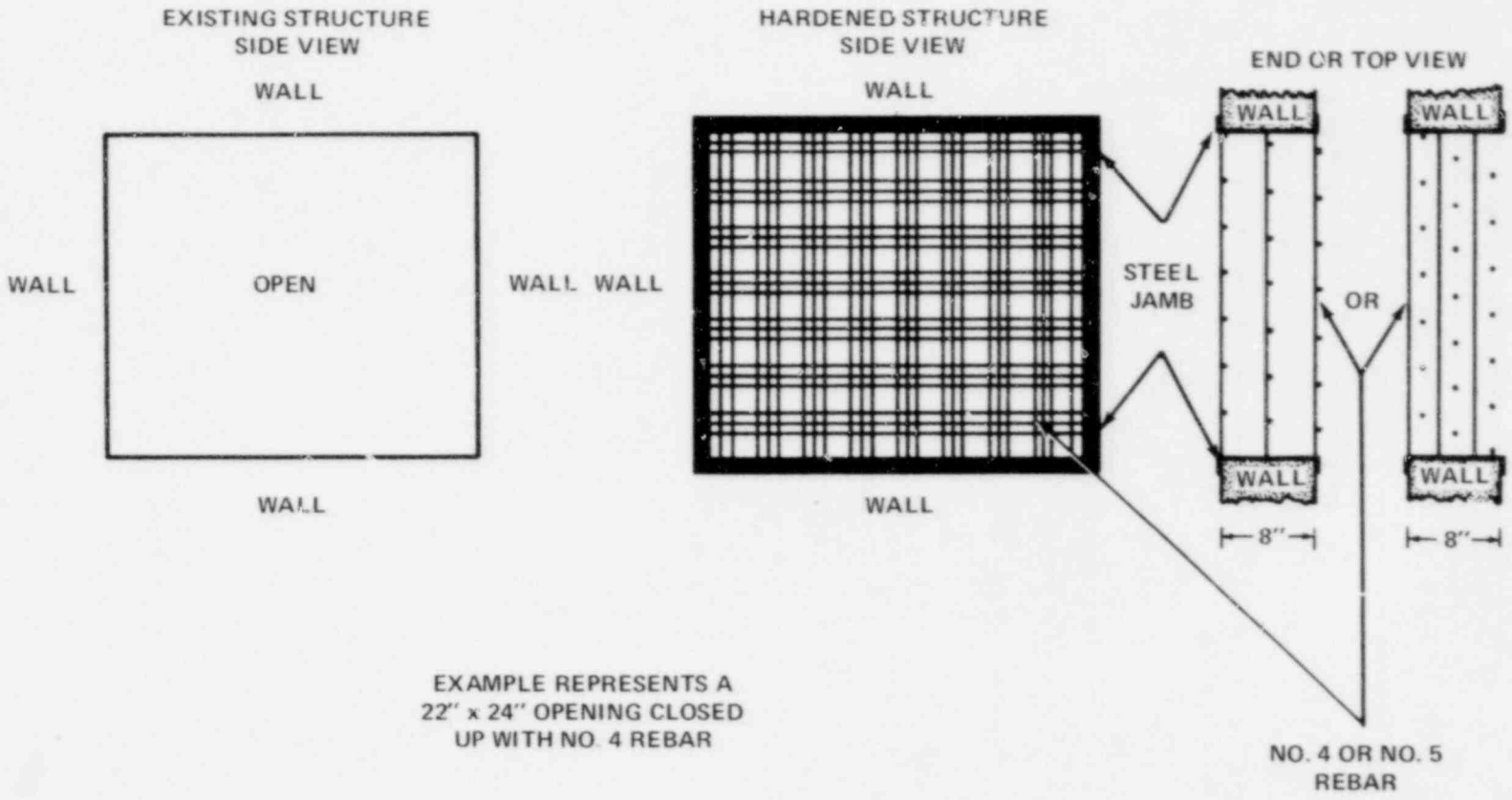
ADDITIONAL TOOLS REQUIRED - Boltcutters

ADVANTAGES OF TECHNIQUE -

1. Multiple layers to penetrate

2. Delay time can be increased by either increasing size of rebar or numbers of rebar.

DIAGRAM 6 – Hardening Opening in Ceiling or Wall




PENETRATION RESISTANCE TIME

0

PENETRATION RESISTANCE TIME

17 MINUTES

Technique No. 7 - Hardening Opening in Ceiling or Wall Where Air Flow is Required

EXISTING STRUCTURE - Opening in ceiling or wall where air flow is required and opening is too small to allow complete body access

TOOLS REQUIRED FOR PENETRATION - Depends on existing opening

PENETRATION TIME - Depends on existing opening

HARDENING ACTION -

1. Bolt ¼" metal shield to inside of vault wall shaped as shown in Diagram 7.

INCREASED PENETRATION RESISTANCE TIME - Approximately 1-2 minutes (for a 4"x 4" opening)

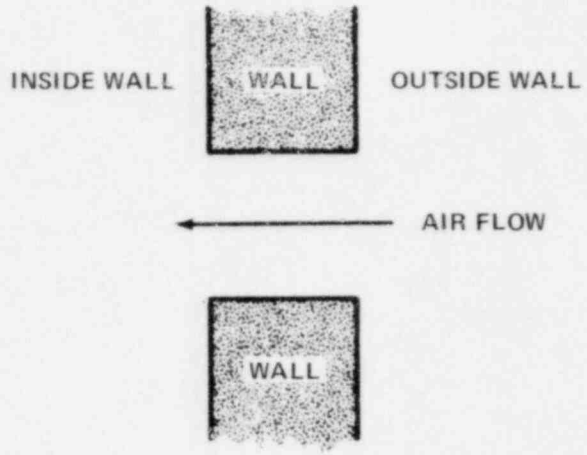
ADDITIONAL TOOLS REQUIRED - Cutting torch

ADVANTAGES OF TECHNIQUE -

1. Prohibits visual observation of vault interior.
2. Allows air flow.
3. Obstructs insertion of arms or grabbers.

DIAGRAM 7 – Hardening Opening in Ceiling or Wall Where Air Flow is Required

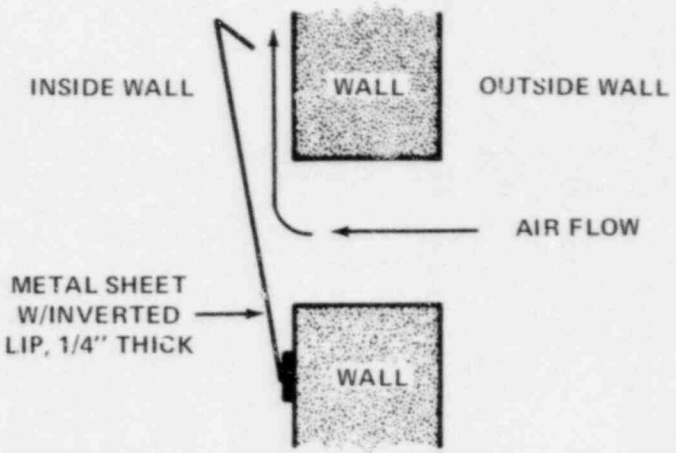
EXISTING STRUCTURE




PENETRATION RESISTANCE TIME

DEPENDS ON EXISTING OPENING

HARDENED STRUCTURE




PENETRATION RESISTANCE TIME

4" x 4" OPENING = 1–2 MINUTES

Technique No. 8 - Hardening Opening in Ceiling or Wall Where Air Flow is Required

EXISTING STRUCTURE - Opening in ceiling or wall where air flow is required and bodily access is possible

TOOLS REQUIRED FOR PENETRATION - Depends on existing opening

PENETRATION TIME - Depends on existing opening

HARDENING ACTION

1. Partially fill opening with material equivalent to or same as existing wall.

2. Bolt a heavy metal pipe elbow on inside of opening

INCREASED PENETRATION RESISTANCE TIME - Approximately 4-6 minutes to completely remove pipe

ADDITIONAL TOOLS REQUIRED - Cutting torch

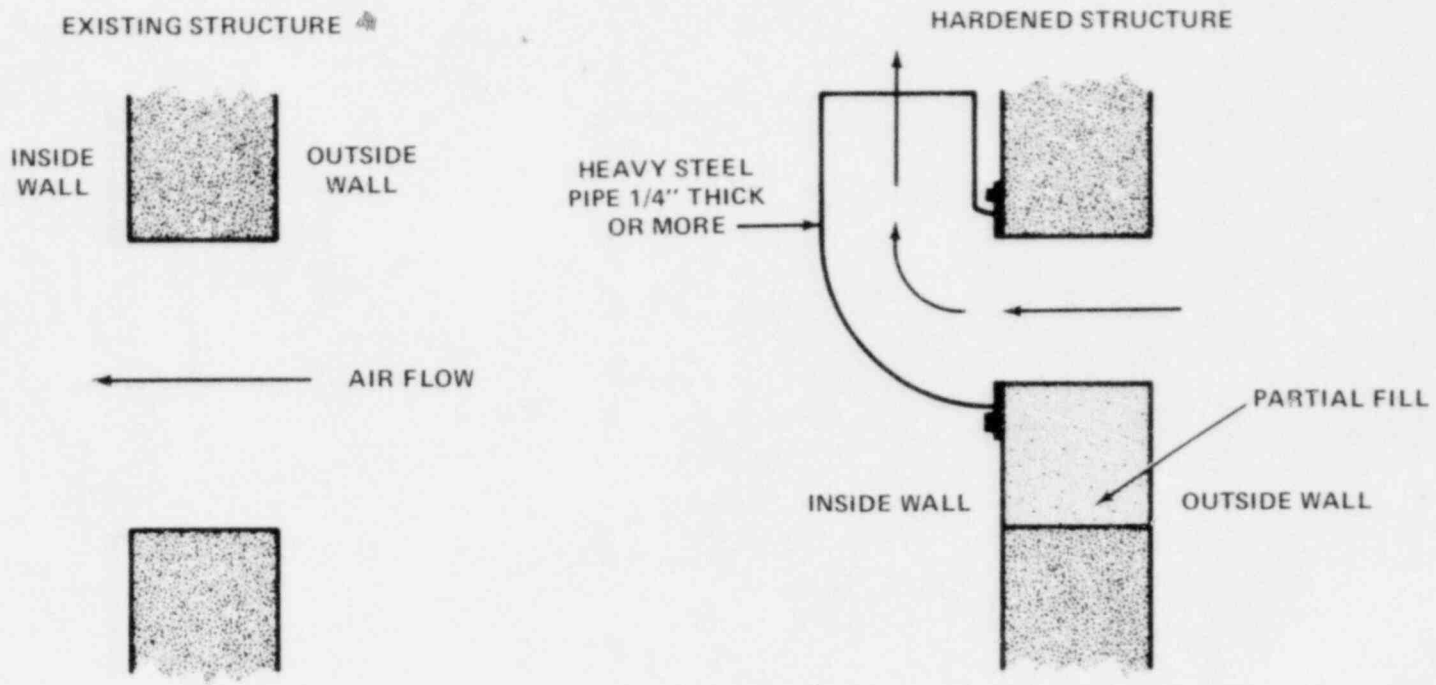
ADVANTAGES OF TECHNIQUE -

1. Reduces bodily access area.

2. Allows air flow.

3. Obstructs observation of vault interior.

DIAGRAM 8 – Hardening of Opening in Ceiling or Wall Where Air Flow is Required
(Large Opening)




EXAMPLE: 8" PIPE, 1/4" THICK

PENETRATION RESISTANCE TIME

DEPENDS ON EXISTING OPENING

PENETRATION RESISTANCE TIME

COMPLETELY REMOVE PIPE –
4–6 MINUTES

Technique No. 9 - Hardening Opening in Ceiling or Wall Where Air Flow is Required

EXISTING STRUCTURE - Opening of any size

TOOLS REQUIRED FOR PENETRATION - Depends on existing opening

PENETRATION TIME - Depends on existing opening

HARDENING ACTION -

1. Add strong steel jamb to opening.
2. Weld steel pipes of 3" diameter or less together and then weld to steel jamb.

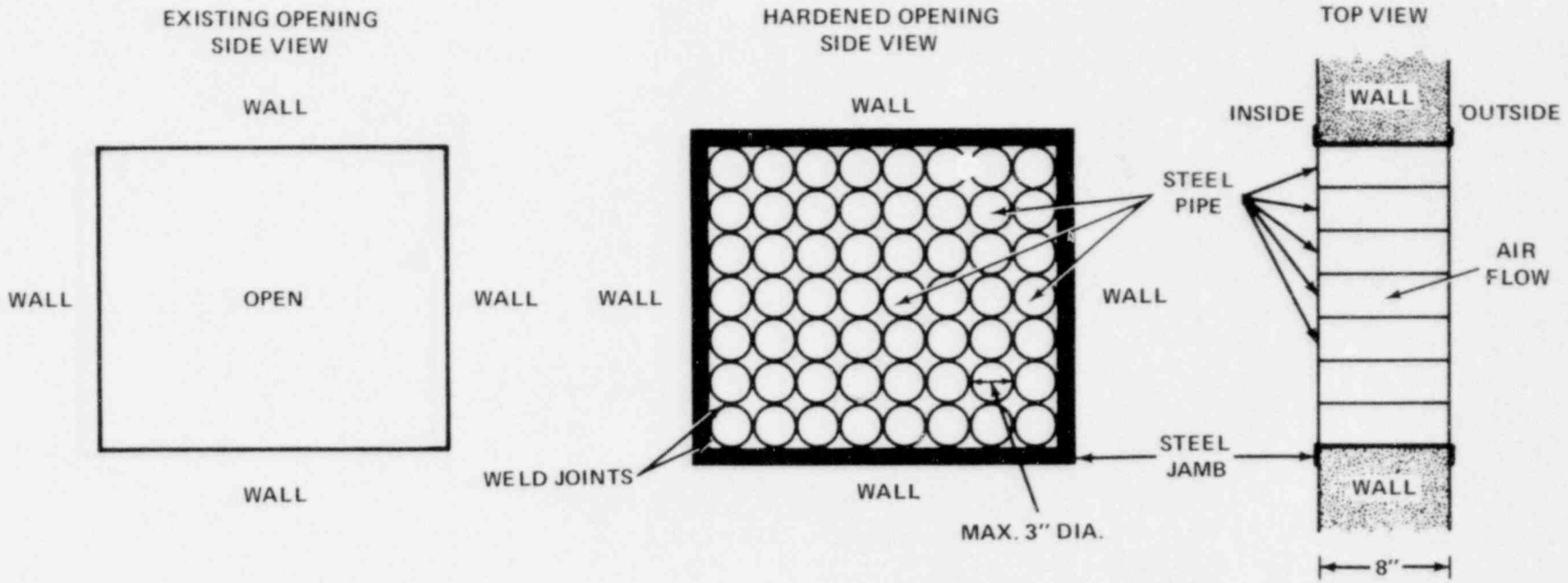
INCREASED PENETRATION RESISTANCE TIME - More than 15 minutes

ADDITIONAL TOOLS REQUIRED - Cutting torch

ADVANTAGES OF TECHNIQUE -

1. Allows air flow.
2. Reduces bodily access.

DIAGRAM 9 – Hardening Opening in Ceiling or Wall Where Air Flow is Required




PENETRATION RESISTANCE TIME

DEPENDS ON EXISTING OPENING

PENETRATION RESISTANCE TIME

MORE THAN 15 MINUTES

Technique No. 10 - Hardening Vault Doorway

EXISTING STRUCTURE - Vault doorway

TOOLS REQUIRED FOR PENETRATION - Depends on existing door

PENETRATION TIME - Depends on existing door

HARDENING ACTION -

1. Weld grate of angle iron or #5 rebar with 4" grid at least 2 feet wider and 1 foot higher than existing vault door.

2. Attach door to inside of vault by either overhead roller track, swinging hinges, or on floor roller track. Hinges, track, and locking system must be unaccessible to the adversary in event vault door was breached.

INCREASED PENETRATION RESISTANCE TIME - Approximately 6-10 minutes

ADDITIONAL TOOLS REQUIRED - Hydraulic boltcutters
Steel cutting saw
Explosives
Cutting torch

ADVANTAGES OF TECHNIQUE -

1. Provides surprise barrier.

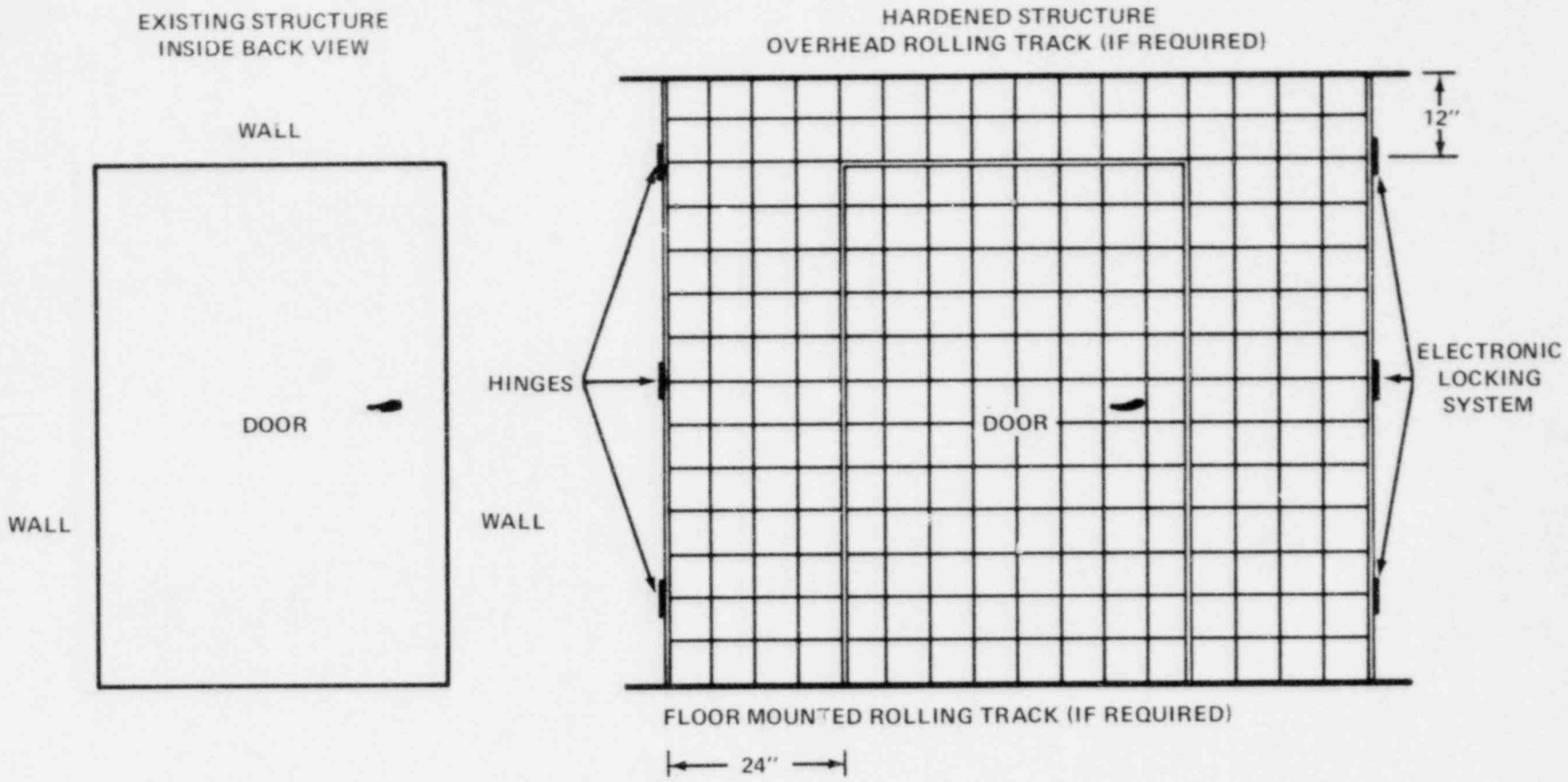
2. Provides an additional barrier.

3. Requires additional tools to penetrate.

4. Can be used for both personnel and vehicle doors.

5. Penetration time can be lengthened by utilizing more or larger rebar.

DIAGRAM 10 – Hardening Vault Doorway




PENETRATION RESISTANCE TIME

DEPENDS ON EXISTING DOOR

PENETRATION RESISTANCE TIME

GRATE OF NO. 5 REBAR – 6–10 MINUTES
GRATE OF ANGLE IRON – APPROXIMATELY 20–30 MINUTES

Technique No. 11 - Hardening Doorway No Longer Required

EXISTING STRUCTURE - Vault doorway no longer required

TOOLS REQUIRED FOR PENETRATION - Depends on existing door

PENETRATION TIME - Depends on existing door

HARDENING ACTION -

1. Weld #5 rebar or angle iron to the door jamb or implant into concrete through the jamb. Rebar can be welded at each intersection to form one solid grate or welded as two separate layers (horizontal and vertical) using a 4" grid.

2. Place a hollow core steel door on the outside portion of the door jamb and spot weld in place.

3. Weld a 4" steel lip of approximately ¼" thickness over entire length of door/jamb seam.

4. Repeat step 2 on the inside portion of the door jamb.

INCREASED PENETRATION RESISTANCE TIME - Approximately 8-30 minutes, depending on material used.

ADDITIONAL TOOLS REQUIRED - Boltcutters
Cutting torch
Explosives
Steel cutting saw

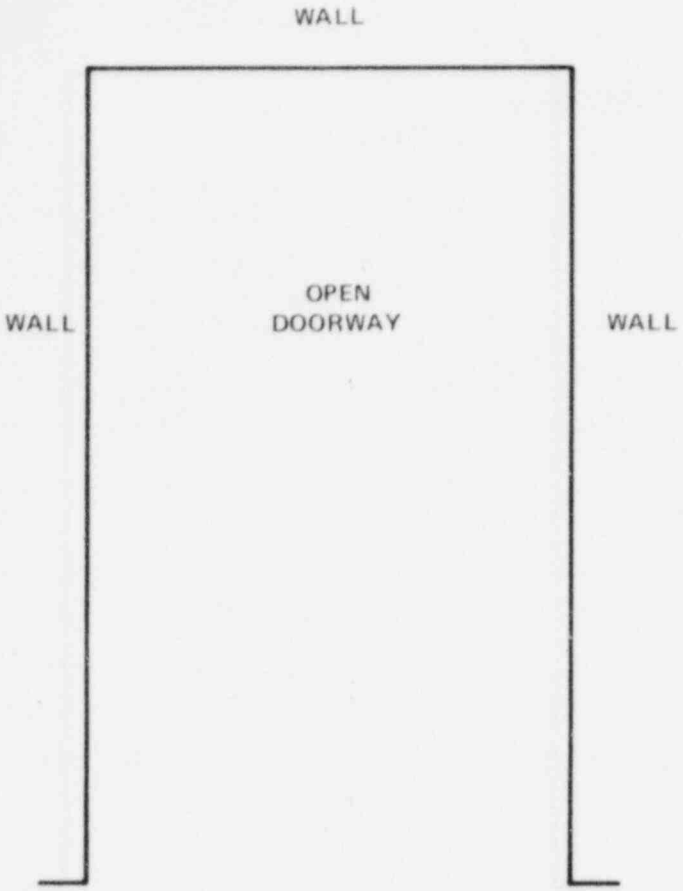
ADVANTAGES OF TECHNIQUE -

1. Vents pressures from explosive penetration attempt.

2. Further penetration resistance can be added by filling inside of doorway with a fill material, adding more rebar, or reinforcing or strengthening doors prior to permanently welding to jamb.

DIAGRAM 11 – Hardening (Seal Up) Doorway No Longer Required

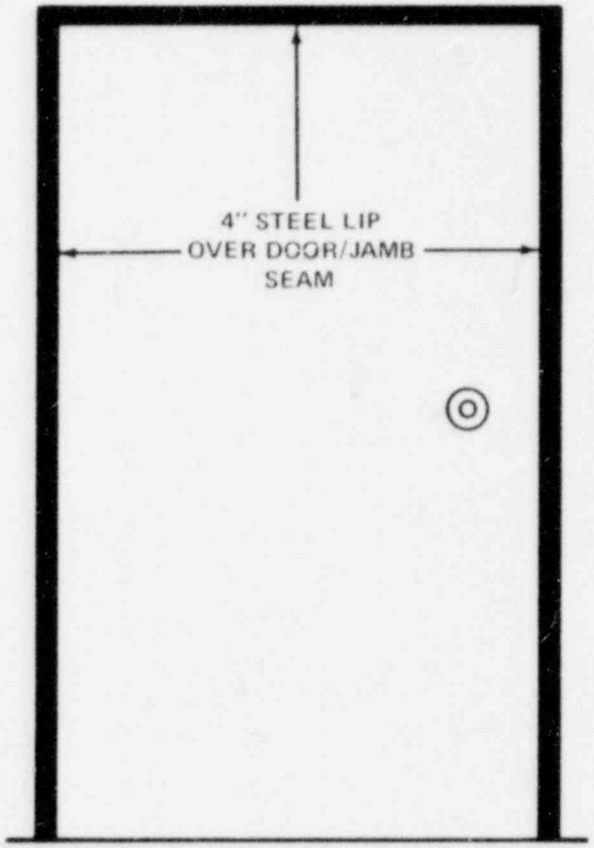
EXISTING STRUCTURE
FRONT VIEW




PENETRATION RESISTANCE TIME

REGULAR HOLLOW CORE DOOR – 30 SECONDS

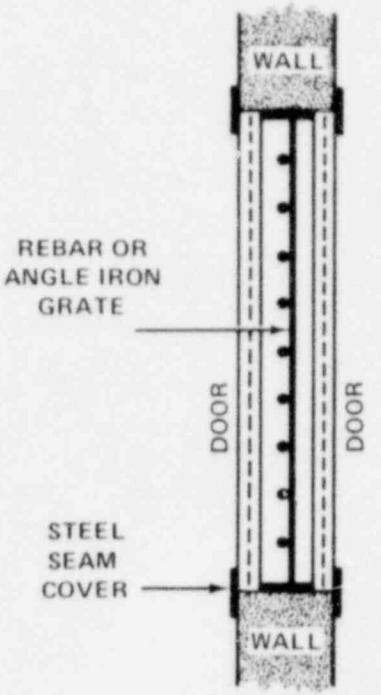
HARDENED STRUCTURE
FRONT VIEW W/DOORS




PENETRATION RESISTANCE TIME

REBAR GRATE – 8–10 MINUTES
ANGLE IRON GRATE – 20–30 MINUTES

TOP
VIEW



Technique No. 12 - Hardening Fire Class or Improving Security Class Doors

EXISTING STRUCTURE - Fire or security class door

TOOLS REQUIRED FOR PENETRATION - Simple explosive charge or cutting torch (back pack portable)

PENETRATION TIME - Approximately 1-2 minutes

HARDENING ACTION -

1. Remove metal panel from back of door and remove existing insulation material.

2. Weld heavy angle iron or small structural I-beam to form a 14" or smaller grid on inside of front panel of door. (The additional metal reinforcement must not interfere with locking system or interlocking pin systems.)

3. Replace insulation or "fill" material as appropriate.

4. Replace metal panel to back of door.

5. Basic skeleton of door, door jamb, or hinges may have to be further hardened to support added weight of door.

INCREASED PENETRATION RESISTANCE TIME - Approximately 20-30 minutes

ADDITONAL TOOLS REQUIRED - Explosives (multiple charges)
Cutting torch (heavier equipment)

ADVANTAGES OF TECHNIQUE

1. Increases penetration delay time.

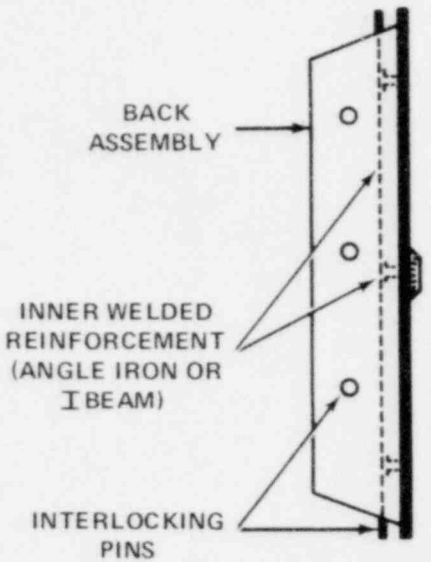
2. Requires different or heavier penetration tools.

3. Easily constructed.

DIAGRAM 12 – Hardening Fire Class or Improving Security Class Doors

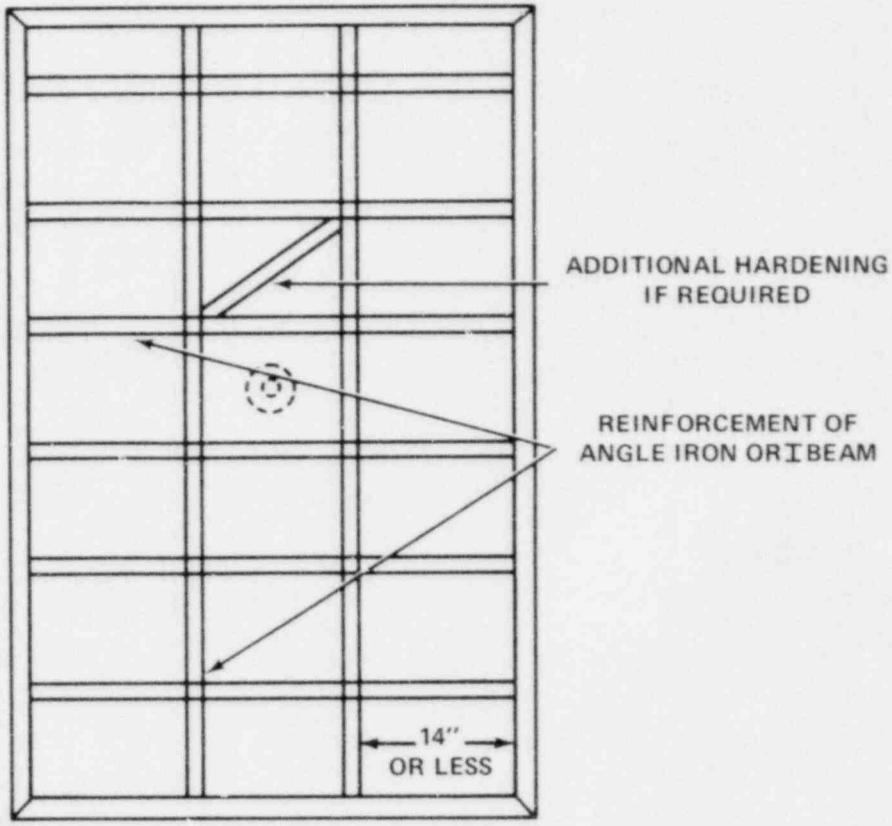
EXISTING DOOR

TOP VIEW




HARDENED DOOR

BACK VIEW WITH REAR COVER REMOVED




PENETRATION RESISTANCE TIME

DEPENDS ON DOOR

PENETRATION RESISTANCE TIME

APPROXIMATELY 20–30 MINUTES

Technique No. 13 - Hardening of Door Utilizing Suppressive Shield Concept

EXISTING STRUCTURE - Common hollow core metal door

TOOLS REQUIRED FOR PENETRATION - Simple explosive charge (less than ½ lb)

PENETRATION TIME - Approximately 30-60 seconds

HARDENING ACTION -

1. Remove metal panel from back of door.
2. Weld ¼" steel louvers on inside of front panel of door 3"-4" apart from top to bottom.
3. Replace back panel of door. (The door frame may have to be reinforced to support the added weight of the door.)

INCREASED PENETRATION RESISTANCE TIME - Approximately 10-15 minutes.

ADDITIONAL TOOLS REQUIRED - Cutting torch
Multiple explosive charges

ADVANTAGES OF TECHNIQUE -

1. Utilizes principle of suppressive shielding.
2. Door can be refitted with heavier exterior panels to provide more resistance.
3. Technique can be used for local construction of new blast-resistant door with only limitation being size of existing door jamb.

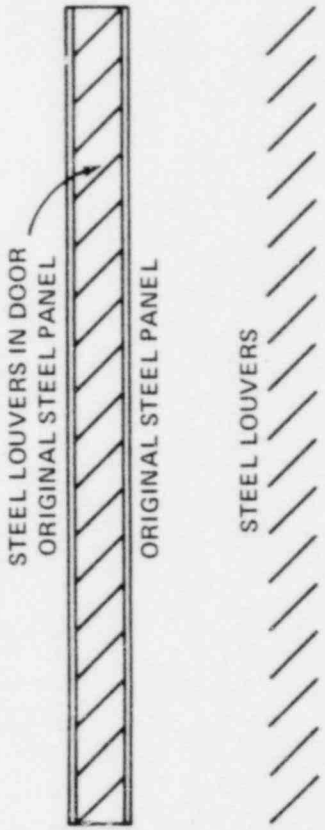
DIAGRAM 13 – Hardening of Door Utilizing Suppressive Shield Concept

EXISTING DOOR

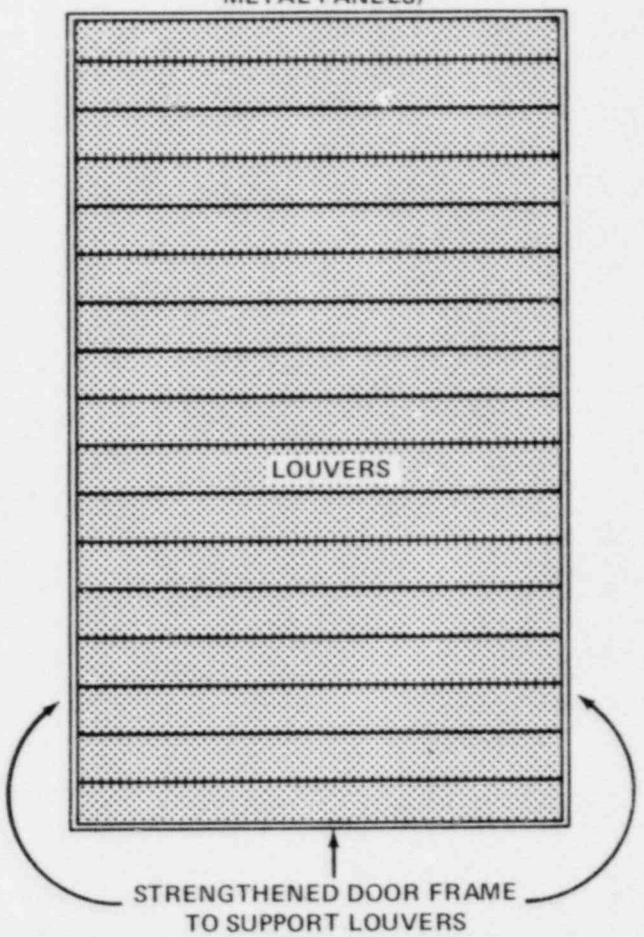
COMMON HOLLOW CORE
STEEL DOOR WITH
16 GUAGE PANEL

HARDENED DOOR

SIDE VIEW




FRONT VIEW (WITHOUT
METAL PANELS)




PENETRATION RESISTANCE TIME

APPROXIMATELY 30–60 SECONDS
TO PENETRATE THROUGH DOOR

PENETRATION RESISTANCE TIME

APPROXIMATELY 10–15 MINUTES
TO PENETRATE THROUGH DOOR

Technique No. 14 - Hardening Door/Jamb Seam, Hinges and Locking Devices

EXISTING STRUCTURE - Any type of door

TOOLS REQUIRED FOR PENETRATION - Hydraulic prying tool

PENETRATION TIME - Approximately 30 seconds

HARDENING ACTION -

1. Weld at least ¼" thick steel strap iron to outer panel of door covering door/jamb seam by at least 2" on all sides.

2. Remove existing hinge from door.

3. Attach a piano or tubular type hinge the entire length of the door to the inner edge of door and jamb.

4. Weld a case hardened steel hinge attached to a case hardened steel cap to the door jamb to cover the door locking device. (The cap should completely cover the locking device.)

5. Weld a case hardened steel hasp to the door to interface with the cap and secure with a high security lock with recessed shackle.

INCREASED PENETRATION RESISTANCE TIME - Approximately 10-15 minutes

ADDITIONAL TOOLS REQUIRED - Cutting torch
Multiple explosive charges
Steel cutting saw

ADVANTAGES OF TECHNIQUE -

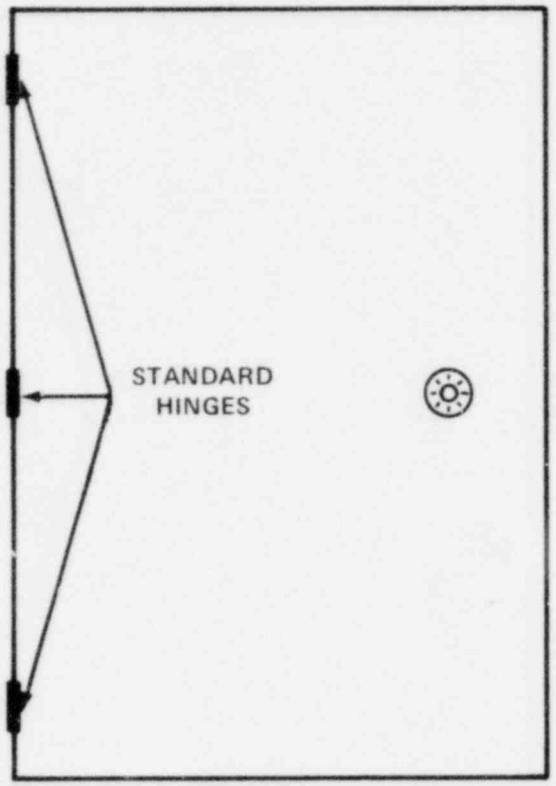
1. Prevents insertion of prying devices.

2. Requires time consuming placement of explosives or use of different tools.

3. Easily constructed.

DIAGRAM 14 – Hardening Door/Jamb Seam, Hinges, and Locking Device

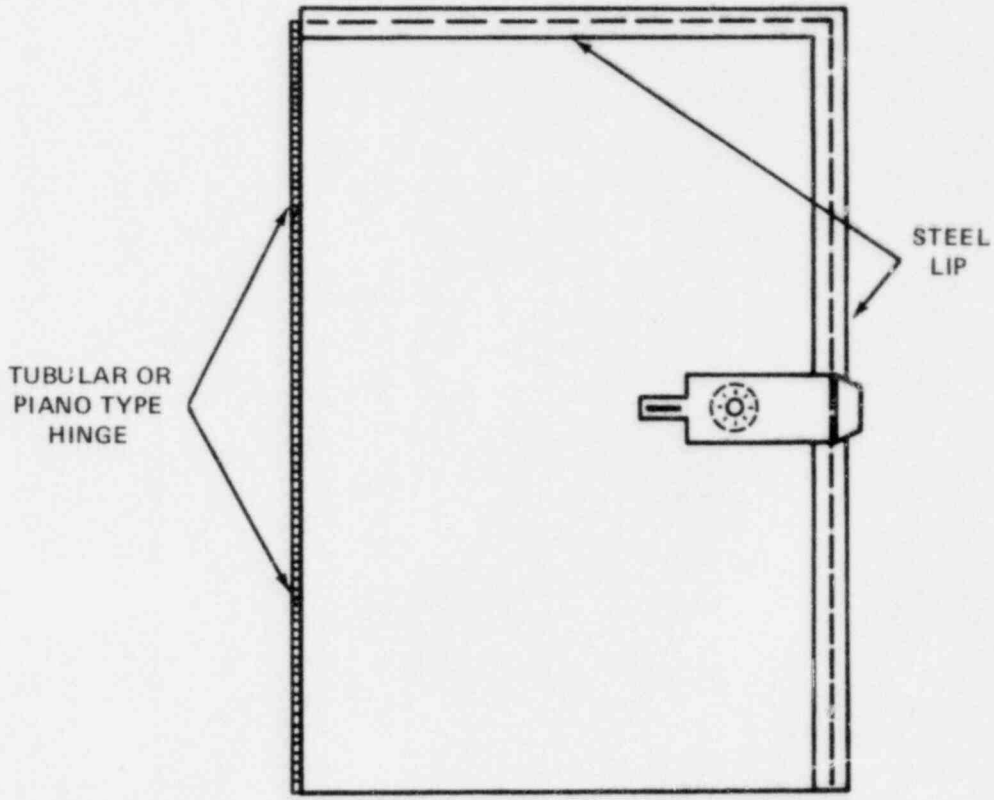
EXISTING DOOR
FRONT VIEW




PENETRATION RESISTANCE TIME

APPROXIMATELY 30 SECONDS

HARDENED DOOR




PENETRATION RESISTANCE TIME

APPROXIMATELY 5–10 MINUTES
(DEPENDING ON TYPE OF DOOR)

Technique No. 15 - Hardening Jambs

EXISTING STRUCTURE - Commonly used wood or light metal jambs

TOOLS REQUIRED FOR PENETRATION - Pry or wrecking bar

PENETRATION TIME - Approximately 5 minutes or less depending on jamb.

HARDENING ACTION -

1. Completely remove existing jamb.
2. Place horizontal and verticle portions of heavy metal structural components into existing opening and weld joints at corners.
3. If wall is concrete block or solid concrete, the structural T or combination jamb should be imbedded in concrete.
4. Structural channel iron can be further reinforced by imbedding pins in concrete and welding to wall side portion of jamb.
5. Install hardened door.

INCREASED PENETRATION RESISTANCE TIME - With hardened jamb it would be easier to penetrate door or wall (no time given)

ADDITIONAL TOOLS REQUIRED - Cutting torch (large)
Burn bar
Wrecking bar
Multiple explosive charges

ADVANTAGES OF TECHNIQUE -

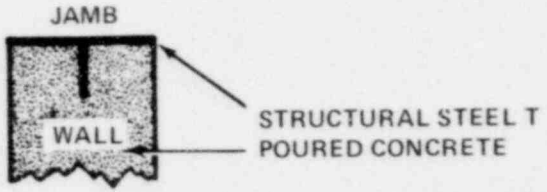
1. Provides strong jamb for hardened door.
2. Requires considerable time to remove, thereby encouraging penetration through door or wall.
3. Easily and inexpensively fabricated locally.

## DIAGRAM 15 – Hardening Jambs

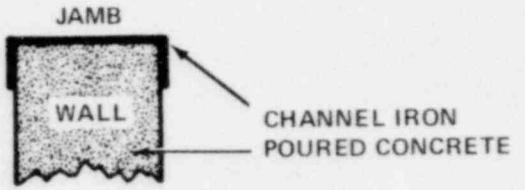
EXISTING STRUCTURE
COMMONLY USED WOOD
OR LIGHT METAL JAMB

HARDENED STRUCTURES
TOP OR SIDE VIEW

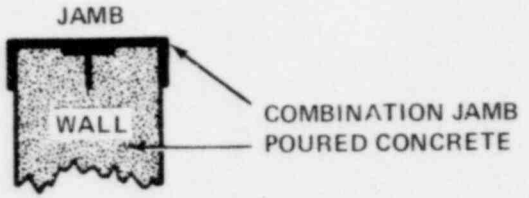
EXAMPLE 1.
STRUCTURAL STEEL T
IMBEDDED IN CONCRETE




EXAMPLE 2.
STRUCTURAL CHANNEL
IRON/STEEL




EXAMPLE 3.
COMBINATION OF
STRUCTURAL T AND
CHANNEL IRON




PENETRATION RESISTANCE TIME

DEPENDS ON EXISTING JAMB

PENETRATION RESISTANCE TIME

DIFFICULT TO ESTIMATE BUT CONSIDERABLY MORE
TIME THAN COMPLETE OR PARTIAL DOOR REMOVAL

Technique No. 16 - Hardening Door Jambs, Hinges, and Locks

The following are additional general guidelines that apply to hardening door components:

Jambs

1. Use case hardened jambs or ones of superior strength.
2. Set jambs into concrete or other barrier material.

Hinges

1. Use multiple hinges (more than the average 3-4).
2. Use single tubular or a piano hinge running the entire length of the door.
3. Provide external covers to hinges to prevent immediate access to hinge.
4. Use hidden hinges (internal to door and jamb).
5. Use case hardened hinges.
6. Attach hinges to the inner edge of door and jamb.
7. Add mechanism that holds door to jamb after hinge failure.

Locks

1. Use multiple locking systems.
2. Use hardened locks with inaccessible internal functions.
3. Use high security locks of case hardened steel or recessed shanks.
4. Use case hardened hasps.
5. Use electrically operated locking devices internal to the vault or door.
6. Locally fabricate internal interlocking pin system.

# 5. APPENDICES

## 5.1 BARRIER PENETRATION DATA

### WALLS

| Type Construction | Personnel Required | Equipment (Wt. lb.) | Average Penetration Time (Min.)(18"D) |
|---|---|---|---|
| 4" Cinder Block w/1/2" mortar seam. | 1 | Sledgehammer (10) | .4 |
| 8" Concrete Block, hollow, non-reinf, 1/2" mortar seam. | 1 | Explosive-Ribbon Charge (3) | .3 |
| 8" Cinder Block, hollow, with #5 rebar on 14" center, mortar bond, mortar filled. | 1 | Sledgehammer, boltcutters (19) | 1.5 |
| 12" Cinder Block, hollow. | 1 | Sledgehammer (10) | 1.2 |
| Fence fabric, 9 gauge, 2" mesh. | 1 | Boltcutters (5) | .32 |
| 8-inch hollow cinder block, 4-inch ferro-cement with six layers of 11-gauge fence fabric. | 3 | Sledgehammer, cutting maul, manual boltcutters, wrecking bar | 21.8 |
| | 3 | Sledgehammer, cutting maul, manual boltcutters, wrecking bar, abrasive blade circular saw | 9.4 |
| | 3 | Sledgehammer, cutting maul, manual boltcutters, wrecking bar, cutting torch | 14.7 |

WALLS

| Type Construction | Personnel Required | Equipment (Wt. lb.) | Average Penetration Time ("in.)(18"D) |
|---|---|---|---|
| 4-inch clay brick, 8-inch hollow cylinder block 1-inch from brick wall with ties every other course, block is mortar-filled with No. 5 rebar on 14-inch centers. | 1 | Sledgehammer | 3.1 |
| 12-inch hollow cinder block, cores filled with mortar, No. 6 rebar on 8-inch centers. | 2 | Sledgehammer, hand hydraulic boltcutters | 5.2 |
| 3/4-inch wood shingles over 3/4-inch wood siding on 2x4 studs, 3/8-inch gypsum board and a solid 5.5-inch layer of wood on opposite side. | 2 | Sledgehammer, cutting maul, wrecking bar, sabre saw, drill | 18.0 |
| | 1 | Sledgehammer, carbide-tipped circular saw | 10.2 |
| Concrete--3000 psi, one layer No. 4 rebar, 8-inch centers. | 1 | Sledgehammer, hand boltcutters | 7.2 |
| | 2 | Explosives, linear shaped charge (0.35), sledgehammer, hand boltcutters | 3.0 |
| | 1 | Explosives (3) tamper plate, hand boltcutters | 2.0 |
| | 1 | Explosives (4), hand boltcutters | 2.2 |

WALLS

| Type Construction | Personnel Required | Equipment (Wt. lb.) | Average Penetration Time (Min.)(18"D) |
|---|---|---|---|
| Concrete--3000 psi, one layer No. 5 rebar, 6-inch centers. | 2 | Rotohammer, drills sledgehammer, chisel, punch, cutting torch | 14.0 |
| | 2 | Explosives (0.35), sledgehammer, hand hydraulic boltcutters | 3.5 |
| | 2 | Explosives (4), tamper plate, hand hydraulic boltcutters | 2.5 |
| | 2 | Explosives (6), hand hydraulic boltcutters | 2.7 |
| | 1 | Explosives (20), platter | 2.0 |
| Concrete--3000 psi, two layers, No. 5 rebar, 6-inch centers. | 2 | Explosives (6), tamper plate, hand hydraulic boltcutters | 4.2 |
| | 2 | Explosives (9), hand hydraulic boltcutters | 4.4 |
| | 2 | Rotohammer, sledge hammer, punch, hand-held power hydraulic boltcutters | 30.0 |

CEILINGS

| Type Construction | Personnel Required | Equipment (Wt. lb.) | Average Penetration Time (Min.) (18"D) |
|---|---|---|---|
| Plaster lath ceiling on gypsum board attached to wood studs with fiberglass insulation. | 1 | Fire axe (5) | 1.0 |
| Celotex laying in suspended channels. | 1 | None | 0.2 |
| Plaster lath ceiling on gypsum board attached to bottom of 4-inch concrete floor with 6-inch, no. 10 wire mesh. | 1 | Tin snips, roto-hammer drill, roto-hammer chisel (30) | 15.0 |
| | | Explosives (0.3), sledgehammer, bolt-cutters, tape (26.3) | 2.0 |

ROOFS

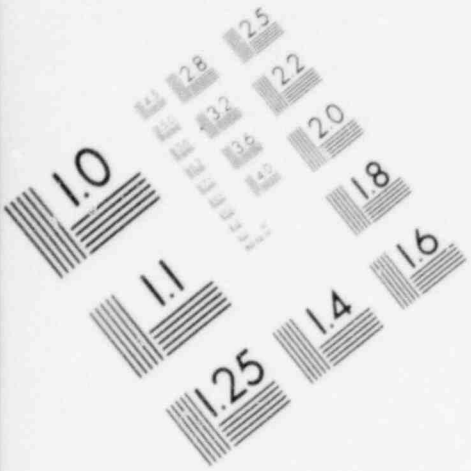
| Type Construction | Personnel Required | Equipment (Wt. lb.) | Average Penetration Time (Min.) (18"D) |
|---|---|---|---|
| Asphalt--built-up roof with gravel, 2-inch rigid insulation, high rib steel decking, 16-gauge. | 2 | Fire axe, shovel (15) | 3.00 |
| | 2 | Fire axe, shovel, circular saw (50) | 2.40 |
| | 1 | Explosives (0.2), | 1.00 |
| Asphalt--built-up roof with gravel, 2-inch celotex rigid insulation on poured 2.5-inch concrete roof. | 3 | Sledgehammer, fire axe, shovel (25) | 2.00 |
| | 1 | Explosives (25) | 1.20 |
| Asphalt--Built-up roof with gravel, 3-inch concrete with vermiculite aggregate, 2-inch celotex rigid insulation, precast T-beam, 2 to 4-inch taper. | 3 | Sledgehammer, fire axe, shovel (25) | 4.7 |
| | 3 | Sledgehammer, fire axe, shovel, circular saw (60) | 12.7 |
| | 1 | Explosives (3) | 1.2 |

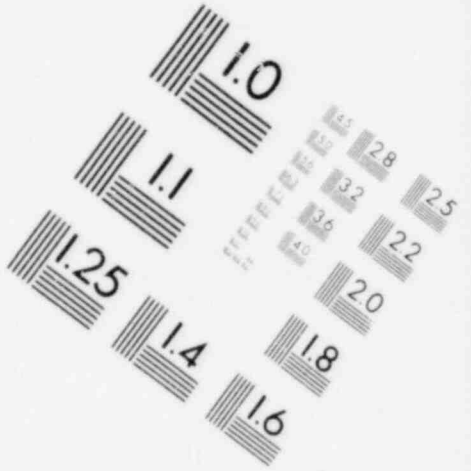
FLOORS

| Type Construction | Personnel Required | Equipment (Wt. lb.) | Average Penetration Time (Min.) (18"D) |
|---|---|---|---|
| 3-inch concrete topping on top of 2.5-inch concrete slab with 6-inch square mesh of no. 10 wire floor on grade. | 2 | Sledgehammer, bolt-cutters (20) | 4.0 |
| | 1 | Explosives (0.3), sledgehammer, bolt-cutters (50.3) | 2.5 |
| 8-inch concrete with 1/2-inch rebar on 12-inch centers each way. | 2 | Tamped explosives (4), hand hydraulic bolt-cutters (32) | 2.0 |
| 4 1/2-inch concrete with 3/8-inch rebar on 18-inch centers poured on steel decking. | 2 | Sledgehammer, fire axe (20.0) | 4.0 |
| | 1 | Explosives, linear shaped charge, fire axe (40.6) | 2.0 |

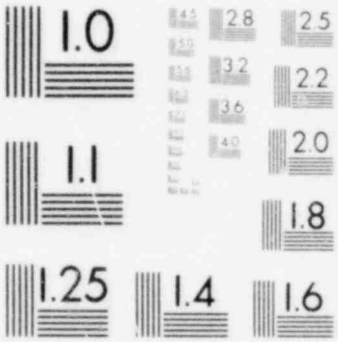
DOORS

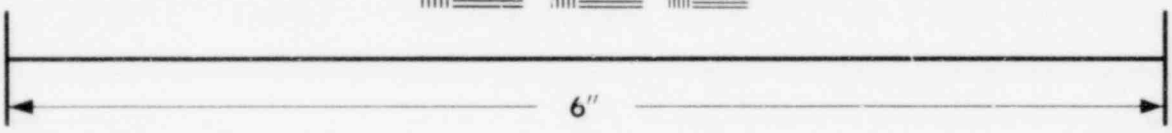
| Type Construction | Personnel Required | Equipment (Wt. lb.) | Average Penetration Time (Min.)(18"D) |
|---|---|---|---|
| 1/4-inch steel plate | 1 | Explosives, bulk (5.1) | 1.00 |
| 1/2-inch steel plate | 1 | Explosives, bulk (10.2) | 1.40 |
| 1-inch steel plate | 1 | Explosives, bulk (20) | 1.80 |
| Personnel, standard hollow core, 18 gauge, butthinge with non-removable pins | 1 | Linear shaped charge explosive (.3) | 1.0 (charge preparation included) |
| Igloo door, 3/8-inch steel, 3-inch void, 1/4-inch steel plate, two Fichet locks | 1 | Explosives, tamped charge-6 (15) | 1.20 |
| | 1 | Circular saw (35) | 3.00 |
| | 2 | Sledgehammer, cutting torch, oxy-lance (75) | 4.40 |
| Igloo door upgraded with redwood center, 3/8-inch steel, 3-inch redwood, 0.036-inch steel | 2 | Sledgehammer, cutting torch, oxy-lance (75) | 12.4 |
| Class 5 vault door | 1 | Thermal tools | 4.00 |
| | 1 | Hand tools | 4.00 |
| | 1 | Hand tools, thermal tools | 2.20 |

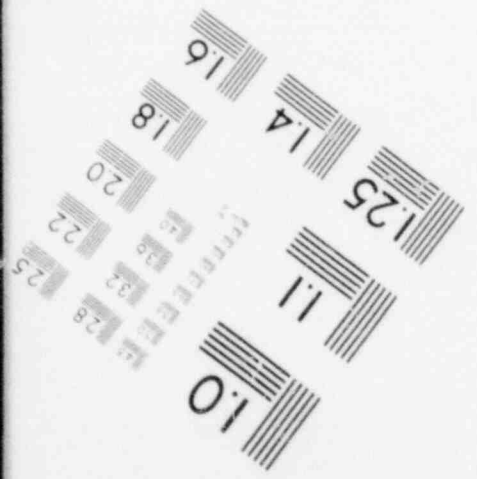


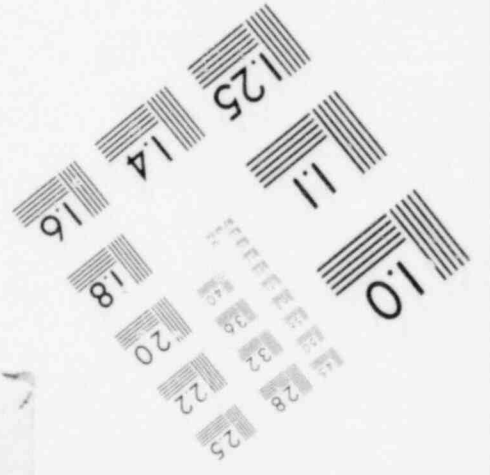



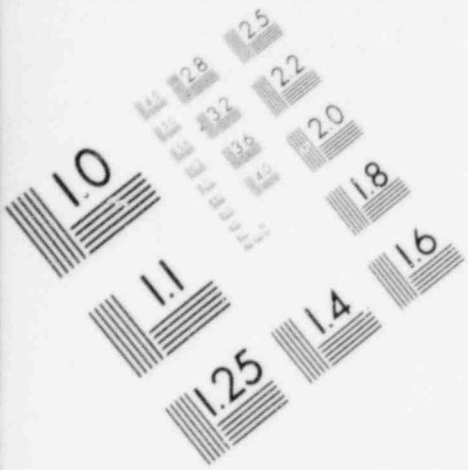

# IMAGE EVALUATION TEST TARGET (MT-3)

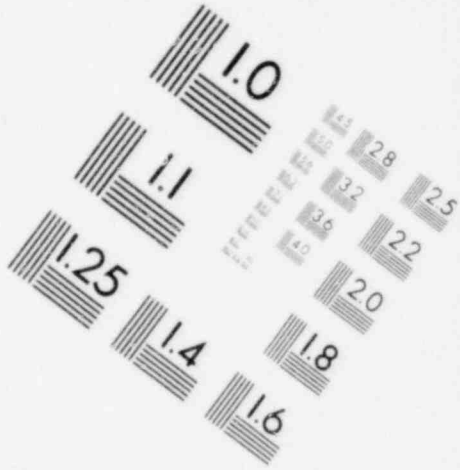


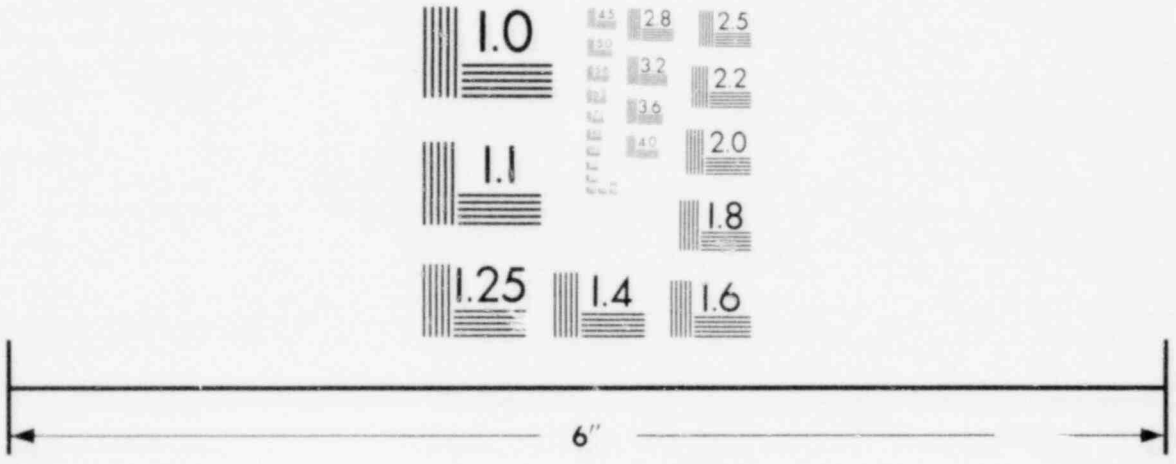



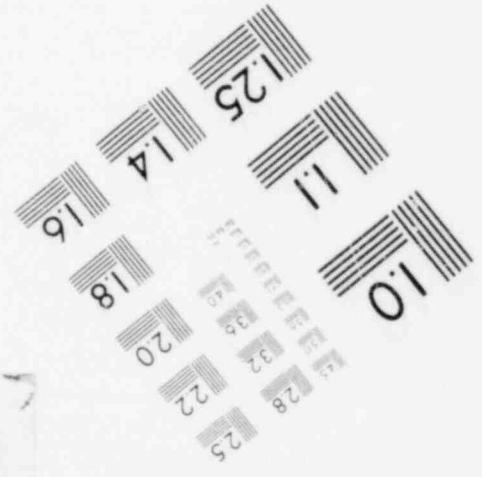



# IMAGE EVALUATION TEST TARGET (MT-3)







## UTILITY PORTS

| Type Construction | Personnel Required | Equipment (Wt. lb.) | Average Penetration Time (Min.) (18"D) |
|---|---|---|---|
| Sheet metal igloo vent with grill of rebar at bottom | 3 | Cutting torch (55) | 3.3 |
| 36-inch dia. roof exhaust, 18- to 24-gauge sheet metal | 1 | Sledgehammer, axe, chisel, tin snips, rope (20) | 2.3 |
| 36-inch dia. roof exhaust with 1/2-inch dia. security bars | 1 | Explosives, linear shaped charge (0.3), sledgehammer, chisel, rope (14.35) | 2.0 |
| | 1 | Sledgehammer, chisel, rope, cutting torch (69) | 1.7 |
| | 1 | Sledgehammer, chisel, hacksaw, rope (14.50) | 3.0 |
| | 1 | Sledgehammer, bolt-cutters, rope (20) | 2.2 |

| Type Construction | Personnel Required | Equipment (Wt. lb.) | Average Penetration Time (Min.) (18"D) |
|---|---|---|---|
| | | HINGES | |
| Standard 4" door hinge (3 each) | 1 | Linear shaped charge explosive (.75) | .3 |
| | | LOCKS | |
| Padlock, high security, case hardened | 1 | Explosive C-4 (.1) | .10 |

## 5.2 COMMONLY USED PENETRATION TOOLS

### Sledgehammer

The sledgehammer is an effective tool for forcible entry. It can be used singularly or in conjunction with other tools. The most effective sledgehammer is in the 6 to 16 pound range; the 10 pound hammer is preferred by most users. In sustained penetrations on a reinforced concrete wall, a sledgehammer user averages approximately 2 seconds per blow. For penetrations requiring 10 to 15 minutes, users usually rest 3 minutes for each minute of work. Small sledgehammers in the 3 to 4 pound range can be used effectively against concrete block construction (non-reinforced) for quick, loss-obtrusive penetrations.

### Maul or Axe

The cutting maul or fireman's axe can be used on weaker materials. Both the maul and axe weigh approximately 6 pounds and are used at the rate of 2 seconds per blow. They are very effective in penetrating composite walls, wood or thin metal pedestrian doors, and built-up roofs consisting of corrugated metal, rigid insulation, and bituminous materials.

### Boltcutters

Boltcutters are used for cutting chains, locks, chain-link mesh fabric, grill-work, and rebar. The size of boltcutters range from 12-42 inches in length. Twelve inch boltcutters are used against lighter materials, while the 42-inch size is used against cables, heavy chain, and #3 to #4 rebar. The rate of use per minute ranges from 30 cuts for chain-link mesh or flattened expanded metal to four cuts for #4 rebar.

Wrecking Bar

Wrecking bars are used to jimmy doors and to lift vents or covers. Common sizes range from 12 to 30 inches in length. About 1 minute is required to pry a door open, while less than 30 seconds is needed to forcibly open a simple vent.

Cutting Torch

Oxygen-acetylene is commonly used for gas welding or cutting. Flame cutting of ferrous metals requries only basic manual skills. One tank of oxygen and one tank of acetylene, together with pressure regulators, hoses, a torch, and cutting attachment, are all that are needed to penetrate most existing metal doors and utility ports. A small backpack model weighing 46 pounds and having a cutting rate of approximately 20 inches per minute for 1/4-inch thick mild steel can be operated for 1 hour. Larger equipment (120 cubic feet) can be utilized at the same rate, but for a period of time exceeding 3 hours.

Oxy-Lance (Burn-Bar)

The oxy-lance or burn-bar is another thermal tool used only for cutting. It can burn through most existing barriers including concrete. The burn-bar consists of a metal tube packed with a number of treated wires coupled to a level control handle, which is connected to an oxygen source. Once the tip of the lance is heated to approximately 1500 degress Fahrenheit by an acetylene torch and oxygen is supplied, the lance begins to burn at temperatures up to 10,000 degrees Fahrenheit. The lance is self-consumable. A 10-foot long lance will be consumed in approximately 3.5 minutes and a standard tank of oxygen (120 cubic feet) can supply oxygen for 3-1/2 units. Typical cutting times per linear inch are 2 seconds for 1/4-inch thick steel plate

and 4 seconds for 1-inch thick steel plate. The burn-bar can also remove reinforced concrete at the rate of approximately 4 seconds per cubic inch.

Explosives

Explosives can be used effectively in penetrating a variety of barriers. Although a number of explosive materials such as dynamite, TNT, etc. are commercially available, it is considered that an adversary would more likely utilize a high efficiency, military explosive such as composition C-4. Large quantities of composition C-4 have been stolen from military depots and it is considered readily available to terrorist groups. Composition C-4 can be easily molded into a variety of shapes, and its use reduces the amount of explosive material required. The adversary must carefully evaluate using explosives because the results could damage material contained within the vault or trigger unwanted chemical or thermal side effects.

Explosive material can be packaged into a variety of charges that are designed to penetrate in specific ways. The following charges are typical of those that may be employed by an adversary.

Linear Shaped Charges are designed to cut through doors, walls and similar barriers. The V-shaped charge cuts a narrow slot along its entire length and can be formed to cut out any sized contour.

Platter Charges are best suited for making penetrations through barriers that are not directly accessible. The platter charge is positioned at a pre-determined distance from the barrier in such a manner that the explosive detonation propels the plate at optinum velocity into and through the barrier.

Satchel or Bulk Breeching Charges are used primarily in breaching barriers where shaped charges are not required. Satchel charges usually consist of a large quantity of bulk explosives packaged in a canvas bag or case.

## 5.3 PENETRATION TOOL WEIGHTS

| HAND TOOLS | WEIGHT (POUNDS) |
|---|---|
| Hammer | <6 |
| Suction Cup | 1 |
| Sledgehammer | 5-10 |
| Sledgehammer | 10-16 |
| Sledgehammer | >16 |
| Cutting Maul | <6 |
| Cutting Maul | >6 |
| Axe | 2-5 |
| Fire Axe | 10 |
| Lock-Picking Tools | 0.5 |
| Punch | <0.5 |
| Chisel | 0.5 |
| Saw, Wood (Carpenters) | 1 |
| Saw, Metal (Hacksaw) | 0.5 |
| Boltcutters, < 24 inches | 5-10 |
| Boltcutters, > 24 inches | 10-20 |
| Hand Hydraulic Boltcutters | 10 |
| Strap Wrench | 0.5 |
| Pliers, < 8 inches | 0.5 |
| Pliers, > 8 inches | 0.5 |
| Pliers, Vise Grip, Med. | 1.0 |
| Shears, Sheet Metal | 0.5 |
| Tin Snips | 0.5 |
| Brace and Bit | 2 |
| S-Hook, 18-inch, Made of Rebar | 0.5 |
| 6-foot Pry Bar | 15 |
| Wrecking Bar | <18 |
| Wrecking Bar | ≥18 |
| Wrecking Bar, < 35 inches | 3 |
| Battering Ram | 50 |
| Hydraulic Pry Bar | 20 |
| Shovel | 5 |
| Pick | 5-10 |
| Posthole Digger | 5 |
| Auger | 10-50 |
| Grappling Hook, 3 barbs | 3 |

| POWER TOOLS | WEIGHT (POUNDS) |
|---|---|
| Saw, Circular, Steel Blade, 8-inch Blade | 20-30 |
| Saw, Circular, Steel Blade, 8 to 12-inch Blade | 20-30 |
| Saw, Circular, Steel Blade, ≥12-inch Blade | 20-30 |
| Saw, Circular, Abrasive Blade, <12-inch Blade | 20-30 |
| Saw, Circular, Abrasive Blade, ≥12-inch Blade | 20-30 |
| Saw, Circular, Diamond Blade, <12-inch Blade | 20-30 |
| Saw, Circular, Diamond Blade, ≥12-inch Blade | 20-30 |
| Chainsaw, <16-inch Bar | 10-15 |
| Chainsaw, ≥16-inch Bar | 15-30 |
| Saw, Circular, Hubless, Steel Blade | 20-30 |
| Saw, Reciprocating (Sabre Saw) | 3 |
| Electric Powered Hydraulic Boltcutters | 17 |
| Gas Powered Hydraulic Boltcutters | 30 |
| Drill, 0.25-inch Chuck | 2 |
| Drill, 0.375-inch Chuck | 3 |
| Drill, 0.5-inch Chuck | 6 |
| Drill, Cordless 0.25-inch Chuck | 4 |
| Drill, Cordless 0.375-inch Chuck | 6 |
| Drill, Cordless 0.5-inch Chuck | 8 |
| Drill, Diamond Core | 90 |
| Rotohammer, Drill | 15 |
| Rotohammer, Chisel | 15 |
| Jackhammer, Pneumatic, with Bits | 100 |
| Saw, Circular, Carbide-Tipped Blade, Gasoline-powered | 35 |

| THERMAL TOOLS | WEIGHT (POUNDS) |
|---|---|
| Powder for Powder Lance | 0-100 |
| Cutting Torch with Tanks, Oxyacetylene | 55 |
| Cutting Torch with Tanks, Mapp | 55 |
| Cutting Torch Hand, W/Powder Attach, Linde C-63 | 100 |
| Oxy-Lance, Small Tank, Gauge, Hose, Two Bars | 100 |

| EXPLOSIVES | WEIGHT (POUNDS) |
|---|---|
| Explosives, Bulk | 0-100 |
| Explosives, Satchel Charge | 0-75 |
| Explosives, Detonating Cord, <100 Grains per foot | |
| Explosives, Detonating Cord, ≥100 Grains per foot | |
| Explosives, Linear Shaped Charge, <100 Grains per foot | |
| Explosives, Linear Shaped Charge, 100 to 500 Grains per foot | |
| Explosives, Linear Shaped Charge, 500 to 2000 Grains per foot | |
| Explosives, Linear Shaped Charge, ≥ 2000 Grains per foot | |
| Explosives, Linear Shaped Charge, Jet-Axe, Ja-1, 3.5 oz, 250 Grains per foot | 19 |
| Explosives, Linear Shaped Charge, Jet-Axe, Ja-2, 1.9 oz, 250 Grains per foot | 9 |
| Explosives, Linear Shaped Charge, Jet-Axe, Ja-3, 5.6 oz, 250 Grains per foot | 27 |
| Explosives, Linear Shaped Charge, Jet-Axe, Ja-4, 5.6 oz, 550 Grains per foot | 26 |
| Explosives, Linear Shaped Charge, Jet-Axe, Ja-5, 3.4 oz, 550 Grains per foot | 11 |
| Explosives, Conical Shaped Charge | <2->20 |
| Explosives, Platter Charge | <10-100 |
| Explosives, Bangalore Toredo | 20 |
| Tamping Material (Typical) | 2 to 3 times weight of explosives |

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This report provides guidelines to aid NRC licensees in evaluating existing strategic special nuclear material storage facilities, discusses typical tools that could be employed to penetrate such facilities, and provides simple and cost effective hardening techniques. The report was developed to provide guidance in support of the Physical Protection Upgrade Rule, effective March 25, 1980.

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