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# **BARRIER PENETRATION DATABASE**

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**Brookhaven National Laboratory**

**Prepared for  
U. S. Nuclear Regulatory Commission**

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This revision replaces the July 1978 edition, which should be destroyed. The availability of more up-to-date barrier penetration performance data makes issuance of this revision necessary.

## CONTENTS

	<u>Page</u>
Acknowledgements.....	4
Introduction.....	5
A. Miscellaneous Barriers.....	7
1. Barbed Tape Obstacle.....	7
B. Fences and Gates.....	8
2. 7' Chain Link Fence.....	8
3. 7' Chain Link Fence with Concertina.....	9
4. 8' Security Gate.....	9
C. Walls.....	10
5. 8" Block Wall.....	10
6. 8" Reinforced Block Wall.....	10
7. Wood Frame Wall.....	10
8. Reinforced Wood Frame Wall.....	11
9. Steel-Plated Wooden Wall.....	11
10. 8" Reinforced Concrete Wall.....	11
11. 12" Reinforced Concrete Wall.....	12
12. 18" Reinforced Concrete Wall.....	12
13. Butler-type Building Wall.....	12
D. Roofs.....	13
14. 5 1/2" Concrete Roof.....	13
15. 24" Soil Cement Roof.....	13
16. Asphalt, Sheet Metal, & Concrete Industrial Roof.....	13

	<u>Page</u>
E. Ceilings.....	15
17. Plaster - Sheet Rock Ceiling.....	15
18. Plaster on Concrete Ceiling.....	15
F. Floors.....	16
19. 8" Concrete Floor.....	16
20. Plywood Floor.....	16
G. Doors.....	17
21. Corrugated Steel Rollup Vehicle Door.....	17
22. Hollow Steel Door.....	17
23. Substantial Steel Door.....	18
24. GSA Class 6 Vault Door.....	18
H. Windows.....	19
25. Expanded Steel Mesh Covered Window.....	19
26. 1/8" Glass Window.....	19
27. Window with Steel Reinforcing.....	19
28. 1" Lexan Window.....	19
I. Utility Ports.....	20
29. Roof Exhaust - Reinforced.....	20
30. Louvered Sheet Metal Port.....	20
J. Cages.....	21
31. Chain Link.....	21
32. Expanded Metal.....	21
Appendix A: Summary Table of Penetration Times.....	22
Appendix B: Average Speeds for Running, Walking, and Climbing.....	25
Bibliography.....	26
Figures.....	27

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The authors owe a clear debt to the compilers of the Sandia Barrier Technology Handbook. In fact, we have merely tried to reduce the Handbook to an easily readable form, adding some other data we have compiled from various sources. We also gratefully acknowledge previous compilations of Dr. J. P. Indusi, which greatly facilitated our search and preparations, and conversations with Dr. F. Viers.

## INTRODUCTION

This document is intended to supply the NRC and nuclear power plant licensees with basic data on the times required to penetrate forcibly the types of barriers commonly found in nuclear power plants. These times are necessary for design and evaluation of the physical protection system required under 10CFR73.55.

Each barrier listed is described in detail. Where minor variations in the basic barrier construction result in essentially the same penetration time, the variations are described. Figures of barriers requiring further clarification are presented in sequential order beginning on p. 27.

For each barrier, the penetration time listed is that for the hand-carried portable countermeasure which would allow fastest penetration. If two alternative countermeasures could penetrate a given barrier in about the same time, both are given. The approximate weights of countermeasures are given in order to allow estimation of the total weight of equipment which might be required to penetrate a given series of barriers.

In some cases, different kinds of countermeasures are specified for very similar barriers. For example, in our discussion of walls, we specify heavy hand tools in some cases and explosives in others. This apparent lack of consistency is due to a lack of systematically collected data. In all cases, we have cited only penetration times which can be substantiated by reference to the literature, and thus consistent data were not always available.

The penetration times are listed with a standard deviation range. This range is intended to give some idea of the possible variations in penetration times which might be expected between several roughly equally experienced adversaries.

The source of the time listed is given for each barrier, and a complete list of the references used appears at the end of the report.

A. MISCELLANEOUS BARRIERS

Barrier 1: Barbed Tape Obstacle. This consists of three side-by-side units made with GPBTO (general purpose barbed tape obstacle). GPBTO consists of two concentric coils of spring steel barbed tape. The coils have opposite spirals, 24 and 30 inches in diameter. A spacing of two feet is maintained between the loops by means of spacer wires. Assembly is 66 feet long, when extended.

Can be crossed in  $18 \pm 3$  seconds without equipment.

Reference: Duke, G.H., and Plugge, N.M., "Personnel Barriers using Barbed Wire or Tape", Sandia Laboratories, August 1974.

## B. FENCES AND GATES

Almost all common types of fences are penetratable in seconds, or, at best, in less than a minute, either by assisted climbovers or by raising the bottom of the sheet of wire mesh and crawling under. Little or no tools are required. Fences, gates and barbed wire are, therefore, deterrents only to the "casual" or less-than-highly-motivated intruder. Otherwise, they provide essentially only alarm information, not a significant delay time.

Note that any of the three barriers listed here can be driven through in a light (pick-up) truck in  $2 + 1$  seconds with no significant damage to the truck.

Barrier 2: 7' Chain Link Fence. Fence fabric is No. 11 American Wire gauge or heavier, with two-inch mesh openings. Fabric should be at least seven feet wide. A top guard is also required: there should be an overhang of barbed wire or tape along the top of the fence facing outward and upward at a 30-45 degrees from vertical. A "V" double overhang may also be used. Minimum of three strands of barbed wire or barbed tape evenly spaced about six inches apart is to be used in each arm of the top guard.

Where there is paved surface or firm ground, the fabric should extend to within 2 inches of ground. Where soft ground, fabric should extend below surface. Any opening greater than 96 square inches under the fence should have the fabric extended to cover it. Posts are to be set in concrete to a depth of at least 36" with a diameter of at least 9" and no more than 10' apart.



Time needed to penetrate (climb over) with no material aids, but having assistance of one man not crossing was  $4.3 \pm 0.3$  seconds.

Reference: Fite, R.A., "Final Report, Joint Services Perimeter Barrier Penetration Evaluation", USAMERADCO, April, 1976.

Barrier 3: 7' Chain Link Fence with Concertina. This is similar to Barrier 2, but with a V-shaped set of two overhangs instead of just one. Between them is coiled barbed wire or tape. Time to penetrate (climb over) is  $8.4 \pm 1.0$  seconds with a carpet and two 2x2's. Weight estimated at 30 lbs.

Reference: Fite, R.A., op. cit.

Barrier 4: 8' Security Gate. Gate is 4' x 8', 11 gauge with 2 inch mesh on a 1.9" metal pipe frame, chained and padlocked. Using a 6-foot pry bar, weighing 15-1/2 lbs., penetration requires  $0.5 \pm 0.1$  minutes. This is for forcible entry.

Reference: "Barrier Technology Handbook", SAND-77-0777.

C. WALLS

Given below are some means of penetrating various walls in a few minutes. It is to be remembered, however, that in all cases of 8" concrete or less (including reinforced wooden walls), 50-60 pounds of explosives and tamping material, plus a 10 pound sledge and perhaps a 10 pound boltcutter, will penetrate in 2-3 minutes. Fibrous concrete generally requires only slightly more explosive charge (six pounds instead of four for an eight inch wall) and some more tamping material, not more time.

Barrier 5: 8" Block Wall. This consists of 8" hollow cinder blocks with mortar filled cores and vertical #5 rebar in cores on 14" ctrs.

A 10 lb. sledge hammer and 10 lb. boltcutters penetrate in 1.5 ± 0.3 minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 6: 8" Reinforced Block Wall. The construction is running bond mortar filled, with #8 rebar in each core.

Using 70 pound cutting torch and sledgehammer, penetration requires 2.7 ± 0.5 minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 7: Wood Frame Wall. Wall is made of 2" x 4" studs with 3/4" shingles inside and out.

A brace and bit with reciprocating saber saw penetrates in 1.4 ± 0.3 minutes. Weight of equipment is 5 lbs.

Reference: "Barrier Technology Handbook", SAND-77-0777; Moore, R.T., NBSTN-73-223.

Barrier 8: Reinforced Wood Frame Wall. Wall has 2" x 4" studs, 3/4" shingles on 3/4" planks, 3/8" gypsum board inside; is reinforced with 3/4" expanded steel mesh and 3/4" plywood.

Sledgehammer, cutting maul, and battering ram (66 lbs) penetrate in  $6.7 \pm 1.4$  minutes.

Note: Although actual test data are not available, manufacturer's specifications and inference from the results of tests on Barriers 13 and 20 suggest that a 27 lb. Jet-Axe JA-III charge could produce a 24" x 36" opening in Barrier 8 in  $1.0 \pm 0.2$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777; Moore, R.T., NBSTN-837.

Barrier 9: Steel-plated Wood Wall. Wall is made of 2x4 studs covered with 3/8" gypsum board on both sides, 1/8" steel plate welded to the back side of 3.6" steel studs.

A 10-pound sledgehammer and an oxyacetylene torch with tanks (65 pounds) need  $2.8 \pm 0.6$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777; Moore, R.T., NBSTN-837.

Barrier 10: 8" Reinforced Concrete Wall. Wall is made of 3000 psi concrete with one layer of #5 rebar on 6" ctrs.

Six pounds of bulk explosives and a 30 pound hand hydraulic bultcutter penetrate in  $3.1 \pm 0.6$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 11: 12" Reinforced Concrete Wall. Wall is 5000 PSI concrete with 5/16" expanded metal on 2.5" centers.

One needs 150 pounds of cutting torch and a 10 lb. sledge hammer together with some six pounds of bulk explosives to get through in  $23 \pm 5$  minutes. A 20 lb. bulk explosive plus a 36 lb. tamper plate take  $2.0 \pm 0.4$  minutes.

Barrier 11a: 12" Reinforced Concrete Wall. This wall differs from Barrier 11 in that it is 3000 PSI concrete, has no expanded metal, and is laced with one layer of #4 rebar on 6" centers. 25 pounds of bulk explosives penetrate in  $2.2 \pm 0.5$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 12: 18" Reinforced Concrete Wall. Wall is constructed of 3000 PSI concrete with 2 layers #4 rebar on 6" centers.

Using 20 pounds of explosives, and a 10 pound hand boltcutter, penetration time is  $3.9 \pm 0.8$  minutes. Inference is that this would work on Barriers 10 and 11 as well.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 13: Butler-Type Building Wall. Walls are 2 layers of 26 gauge (0.079") galvanized steel separated by about 1 1/2" foam insulation. Note that the penetration times given assume that there are no doors or windows which would be more vulnerable than the building wall.

Should be about the same as a sheet metal and fiberglass insulation roof which has thicker sheet metal. Twenty pounds of Jet-Axe JA-I require  $0.8 \pm 0.2$  minutes. 10 1/2 pounds of fire ax and gloves take  $1.0 \pm 0.2$  minutes. This is an upper limit for Butler buildings.

Reference: "Barrier Technology Handbook", SAND-77-077.

D. ROOFS

Roofs have a wide variety of constructions, analogous to walls and floors. Penetration problems are clearly similar for similar materials; i.e., an 8" concrete wall presents roughly the same problem as an 8" concrete roof or floor, except that the penetrator will have to try to avoid falling through the horizontal surface once a hole is punched through. We present here typical roofs with penetration times using reasonable tools.

Barrier 14: 5 1/2" Concrete Roof. Roof is 5 1/2" thick concrete with No. 4 rebar on 8"x12" centers midway through the concrete.

With 4 pounds of bulk explosives and 20 pound manual boltcutters, penetration takes  $2.8 \pm 0.4$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 15: 24" Soil Cement Roof. Roof consists of two feet of soil, cement, and water densely compacted. Twenty pounds of explosives take  $2.8 \pm 0.4$  minutes to penetrate.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 16: Roof With Asphalt & Sheet Metal. This is one quite typical roof used in industry and government. Sheet metal of 16 gauge is placed on ribbed steel decking. Two inches of insulation follow. This is covered with 1/2" asphalt and gravel. A ten-pound fire axe and five-pound shovel penetrate in  $2.3 \pm 0.7$  minutes. Twenty pounds of Jet-Axe JA-I charge and equipment do the job in  $0.8 \pm 0.2$  minutes.

Barrier 16a: Asphalt and Concrete Roof. Replace the sheet metal in Barrier 16 above with 2 1/2" of concrete. Jet-Axe JA-IV (26 lbs.) penetrates in 0.9 + 0.2 minutes.

There are quite a few variants with various combinations of a few inches of concrete, sheet metal, and asphalt. They all require about a minute with a few pounds of appropriate explosive.

Reference: "Barrier Technology Handbook", SAND-77-0777.

E. CEILINGS

Ceilings may be nothing more than plaster or gypsum board, and they also may be resistant, including some thickness of concrete. In the latter case, numbers from corresponding wall, roof or floor thicknesses are appropriate.

Barrier 17: Plaster/Sheet-Rock Ceiling. This is a fairly typical weak ceiling with 3/4" plaster on metal lath with 1/4" gypsum board. The board is attached to wood studs with 3 1/2" insulation between studs.

A five-pound fire-axe penetrates in  $1.0 \pm 0.2$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 18: Plaster on Concrete Ceiling. At the other end of the scale is this reinforced ceiling of 4" concrete with 6"x6" No. 10 wire mesh. A 3/4" plaster lath is attached to a 1/4" gypsum board. Both are attached to the concrete.

Penetration is achieved with JA-IV Jet-Axe explosive, a ten-pound boltcutter and a ten-pound sledge, giving about 46 pounds of equipment. Time is  $2.4 \pm 0.5$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

F. FLOORS

Again we note the basic similarity to walls, roofs, and ceilings, floors being only the other side of the coin, as it were. We present some typical examples.

Barrier 19: 8" Concrete Floor. Floor is 8" of concrete reinforced with  $\frac{1}{2}$ " rebar on 12"x12" centers.

Four pounds of bulk explosives, tamping material, and hand hydraulic boltcutters (32 pounds in all) require  $1.9 \pm 0.4$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 20: Plywood Floor. This is a typical wood floor found in portable buildings with 1 1/2" of plywood with fiber glass insulation supported by chickenwire. The whole is covered by a carpet.

Using a Jet-Axe JA-I shaped charge together with associated equipment (20 pounds) one needs  $0.8 \pm 0.2$  minutes. Tin snips and a circular saw (about 23 pounds) require  $0.9 \pm 0.2$  minutes, about the same within errors.

Reference: "Barrier Technology Handbook", SAND-77-0777.



G. DOORS

A wide variety of doors is covered. Again, the weakest are susceptible to breaching by hand tools in minutes. Larger ones generally require more time or more weight of explosives.

Barrier 21: Corrugated Steel Roll-up Vehicle Door. This is a standard door common in many industrial and government installations in the country. The steel is 16 gauge and satisfies AEC specifications in Section 8C of 1970.

Penetration times are:

- a.  $0.7 \pm 0.1$  min. with 30 lbs. of Jet-Axe charge or
- b.  $0.8 \pm 0.2$  min. with a 6-foot pry-bar and a 2"x4" plank weighing about 20-25 pounds together.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 22: Hollow Steel Door. This is the standard industrial pedestrian door. It is a composite door with 18 gauge metal facing, hung on butt hinges with non-removable pins, with a cylinder lock and panic hardware as appropriate. If installed as an emergency-only exit, it is assumed to open outward with its hinges on the outside and to have no hardware on the outside. The door is assumed to have no ventilation louvres or glass.

Many methods may be used to get through these doors in one minute or less. If a knob is accessible, the locking mechanism can be broken using a 1/2 lb. pipe wrench in  $0.4 \pm 0.08$  minutes. The door can be pried open using a 15 lb. pry-bar in  $0.2 \pm 0.04$  minutes, or broken through using a ten-pound fire axe in  $3.8 \pm 0.8$  minutes.

It should be noted however, that these doors can be made more penetration-resistant. For example, steel plates bolted to the face of the door increase its resistance to direct penetration. Use of multiple deadbolts which go into all four sides of the frame increases the door's resistance to being pried open or having its hinges broken. Locking hardware can be installed which cannot be broken by forcing the knob. However, a few pounds of bulk explosive will penetrate in about 1 minute.

For a detailed discussion and analysis of methods of attack and vulnerabilities of a wide range of doors, see Chapter 6 of the Sandia "Barrier Technology Handbook".

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 23: Substantial Steel Door. This is a door made of 3/4" steel on one side, 1/8" steel on the other, filled with 3" fiberglass. It is assumed that the hinges and locking hardware are such that they cannot be broken or pried open.

Ten pounds of bulk explosives require  $1.5 \pm 0.3$  minutes to blow a hole in the door.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 24: Vault Door. Door is GSA class 6 vault, satisfying federal regulations AA-D-600B. It has 3/8" hard drill resistant steel. A 200 pound rocket torch requires  $9.5 \pm 1.9$  minutes to penetrate. However, the inference from results of Barrier 23 is that the door could also be penetrated in  $1.5 \pm 0.3$  minutes by means of ten pounds of a bulk explosive.

Reference: "Barrier Technology Handbook", SAND-77-0777.

H. WINDOWS

Barrier 25: Expanded Steel Mesh Covered Window. This barrier is a window with smaller than man-sized panes of 1/8" glass covered with expanded metal mesh fastened with rivets, set in a standard sash.

A five-pound wrecking bar needs  $1.0 \pm 0.2$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 26: Glass Window, 1/8" Thick. A small hammer needs  $0.5 \pm 0.1$  minutes.

Reference: Moore, R.T., NBSIR-73-223.

Barrier 27: Window with Steel Reinforcing. 1/2" steel rod covering over 1/8" larger than man-sized glass panes.

Sixty pounds of cutting torch, tanks, and hammer need  $0.6 \pm 0.1$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 28: Lexan Window. No data can be found on lexan penetration times. However, it can be readily penetrated in minutes with a drill and saber saw weighing only 10 pounds or so. We would estimate, very roughly, a time of  $5 \pm 2$  minutes through one inch of lexan.

Another possible method for penetrating these windows might be to burn them, using lighter fluid or gasoline to start the fire. Penetration time should be about the same as using a drill and sabre saw.

I. UTILITY PORTS

There are several variants on air conditioning ducts, etc., covered with a grill of steel bars or sheet metal. Two typical examples are taken.

Barrier 29: Roof Exhaust-Reinforced. Port is 36" in diameter with 1/2" security bars. Sheetmetal is 18-24 gauge.

Using about 40 pounds of Jet-Axe JA-IV, associated equipment, a sledgehammer, a chisel, and a rope,  $1.0 \pm 0.2$  minutes are needed. Sledgehammer, chisel, hacksaw and rope (15 pounds) need  $4.3 \pm 0.9$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

Barrier 30: Louvered Sheet Metal Port. This is an air conditioning filter frame bank, 20"x20"x2" with louvers.

A two-pound wrecking bar needs  $0.5 \pm 0.1$  minutes.

Reference: "Barrier Technology Handbook", SAND-77-0777.

J. CAGES

Often in commercial facilities additional physical barriers around vital areas or equipment are provided by the use of cages with chain-link or expanded metal mesh walls. The penetration times listed below are those for actual penetration of the wall, that is, for cutting a man-sized hole through the fabric of the wall.

Note that other means of penetration may be still faster. For example, if the entrance to the cage is padlocked, the lock can be rapped or shimmed in seconds. Use of cylinder-locked deadbolts eliminates this vulnerability. Similarly, exposed hinges or locks integral with doorknobs can be quickly broken. In general, care must be taken in designing and installing cages so that the fabric of the walls is the weakest point and no other vulnerable points such as mentioned above are left.

Barrier 31: Chain-link Fabric. Seven pound boltcutter requires  $0.32 \pm 0.07$  minutes to make a man-sized hole.

Reference: Moore, R.T., NBSTN-837.

Barrier 32: Expanded Metal Mesh Fabric. This should be similar to Barrier 25. Using a five-pound wrecking bar,  $1.0 \pm 0.2$  minutes should be an upper limit.

Reference: "Barrier Technology Handbook", SAND-77-0777.

## Appendix A: Summary Table of Penetration Times

(Note: See text and figures for details of barriers and countermeasures.)

<u>Barrier</u>	<u>Countermeasure</u>	<u>Countermeasure Weight</u>	<u>Penetration Time</u>
1. Barbed Tape Obstacle	none	0	18 <sub>+</sub> 3 sec
2. 7' Chain Link Fence	none (1 extra person to assist)	0	4.3 <sub>+</sub> 0.3 sec
3. 7' Chain Link Fence w/Concertina	carpet and 2 2x2s	30 lbs.	8.4 <sub>+</sub> 1.0 sec
4. 8' Security Gate	6' pry bar	15 lbs.	0.5 <sub>+</sub> 0.1 sec
5. 8" Block Wall	sledge hammer & boltcutters	20 lbs.	1.5 <sub>+</sub> 0.3 min
6. 8" Reinforced Block Wall	sledge hammer & cutting torch	70 lbs.	2.7 <sub>+</sub> 0.5 min
7. Wood Frame Wall	bit & brace, saber saw	5 lbs.	1.4 <sub>+</sub> 0.3 min
8. Reinforced Wood Frame Wall	sledge hammer, cutting maul, & battering ram	66 lbs.	6.7 <sub>+</sub> 1.4 min*
9. Steel-Plated Wood Wall	sledge hammer & oxyacetylene torch	65 lbs.	2.8 <sub>+</sub> 0.6 min
10. 8" Reinforced Concrete Wall	bulk explosives, 48" bolt- cutter	26 lbs.	3.1 <sub>+</sub> 0.6 min
11. 12" Reinforced Concrete Wall with Expanded Metal	bulk explosives, cutting torch, & sledge hammer bulk explosives & tamper	166 lbs. 56 lbs.	23 <sub>+</sub> 5 min 2.0 <sub>+</sub> 0.4 min
11a. 12" Reinforced Concrete Wall without Expanded Metal	bulk explosives	25 lbs.	2.2 <sub>+</sub> 0.5 min
12. 18" Reinforced Concrete Wall	explosives & boltcutter	30 lbs.	3.9 <sub>+</sub> 0.8 min

\* Note: Although actual test data are not available, manufacturer's specifications and inference from the results of tests on Barriers 13 and 20 suggest that a 27 lb. Jet-Axe JA-III charge could produce a 24" x 36" opening in Barrier 8 in  $1 \pm 0.2$  minutes.

## Appendix A: Summary Table of Penetration Times (Cont'd)

<u>Barrier</u>	<u>Countermeasure</u>	<u>Countermeasure Weight</u>	<u>Penetration Time</u>
13. Butler-type Building Wall	Jet-Axe JA-I fire axe & gloves	20 lbs. 10.5 lbs.	0.8+0.2 min 1.0+0.2 min
14. 5½" Concrete Roof	bulk explosives & boltcutter	24 lbs.	2.8+0.4 min
15. 24" Soil Cement Roof	bulk explosive (3 charges)	60 lbs.	2.8+0.4 min
16. Asphalt & Sheet Metal Roof	fire axe and shovel Jet-Axe JA-I	15 lbs. 20 lbs.	2.3+0.7 min 0.8+0.02 min
16a. Asphalt & Concrete Roof	Jet-Axe JA-IV	26 lbs.	0.9+0.2 min
17. Plaster/Sheet-Rock Ceiling	fire axe	5 lbs.	1.0+0.2 min
18. Plaster on Concrete Ceiling	Jet-Axe JA-IV, sledge hammer & boltcutter	46 lbs.	2.4+0.5 min
19. 8" Concrete Floor	bulk explosives, tamping & hand hydraulic boltcutters	32 lbs.	1.9+0.4 min
20. Plywood Floor	Jet-Axe JA-I tin snips & circular saw	20 lbs. 23 lbs.	0.8+0.2 min 0.9+0.2 min
21. Corrugated Steel Vehicle Door	Jet-Axe JA-I pry bar & 2x4 plank	30 lbs. 20-25 lbs.	0.7+0.1 min 0.8+0.2 min
22. Hollow Steel Door	pipe wrench (on doorknob) pry bar fire axe bulk explosives	½ lb. 15 lbs. 10 lbs. 10 lbs.	0.4+0.08 min 0.2+0.04 min 3.8+0.8 min ~1 min
23. Substantial Steel Door	bulk explosives	10 lbs.	1.5+0.3 min
24. GSA Class 6 Vault Door	rocket torch bulk explosives	200 lbs. 10 lbs.	9.5+1.9 min 1.5+0.3 min
25. Expanded Metal Covered Window	wrecking bar	5 lbs.	1.0+0.2 min
26. Glass Window	hammer	> 1 lb.	0.5+0.1 min
27. Window w/½" Steel Rod	cutting torch & hammer	60 lbs.	0.6+0.1 min

## Appendix A: Summary Table of Penetration Times (Cont'd)

<u>Barrier</u>	<u>Countermeasure</u>	<u>Countermeasure Weight</u>	<u>Penetration Time</u>
28. Lexan Window	drill & saber saw	10 lbs.	5+2 min (estimated)
29. Roof Exhaust - Reinforced	Jet-Axe JA-IV, sledge hammer, chisel, & rope	40 lbs.	1.0+0.2 min
	sledge hammer, chisel, hack- saw & rope	15 lbs.	4.3+0.9 min
30. Louvered Sheet- metal Port	wrecking bar	2 lbs.	0.5+0.1 min
31. Chain-link Cage	boltcutter	7 lbs.	0.32+0.07 min
32. Expanded Metal Cage	wrecking bar	5 lbs.	1.0+0.2 min



## Appendix B: Average Speeds for Running, Walking, &amp; Climbing

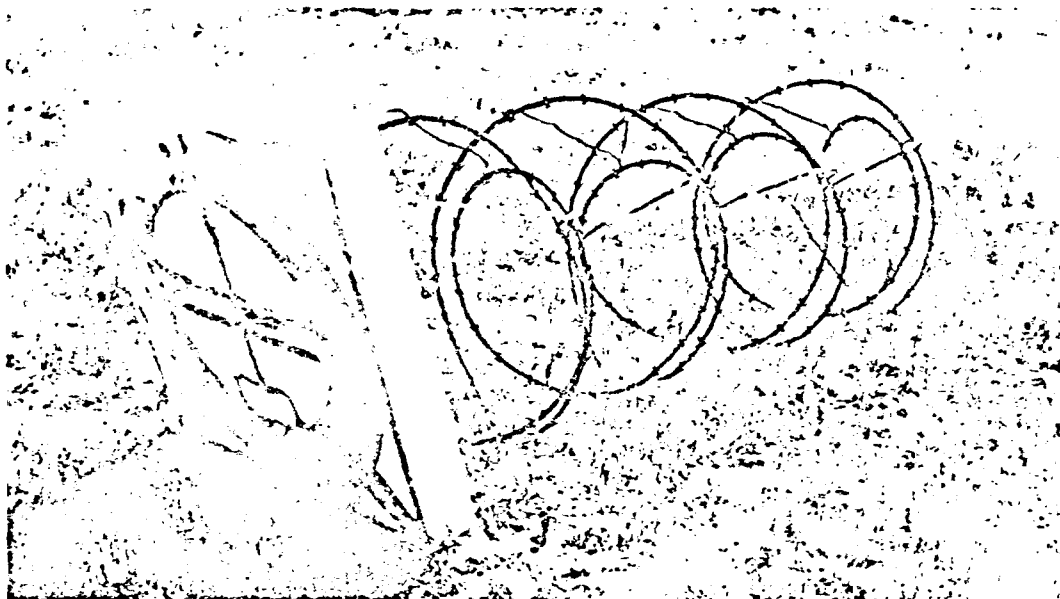
	<u>Normal</u>	<u>Carrying 30 lbs.</u>
Walking	6 $\pm$ 1.5 feet/sec.	5 $\pm$ 1.5 feet/sec.
Running (over 300 ft.)	25 $\pm$ 5 feet/sec.	20 $\pm$ 5 feet/sec.
Climbing Ladder (12 feet vertical)	3 $\pm$ 1 second	8 $\pm$ 2 seconds

Note: These rates are approximate estimates only, based on experiments conducted by the authors.

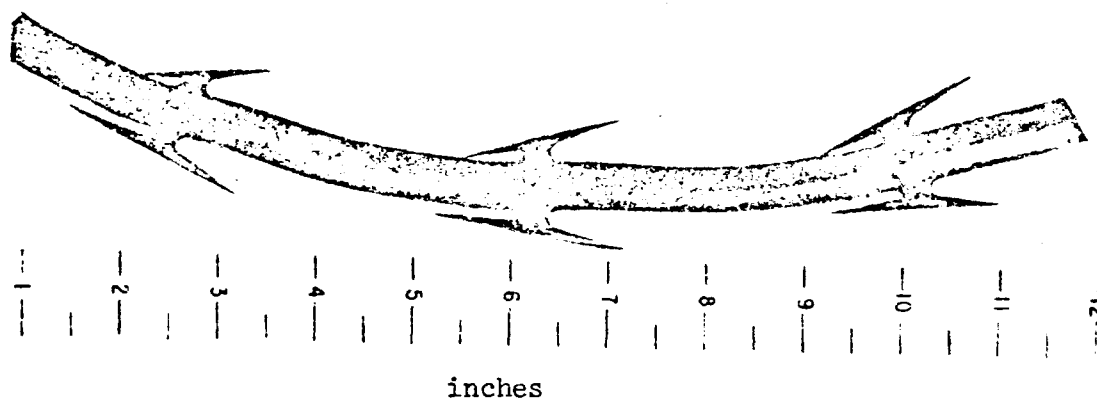
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1. "Barrier Technology Handbook", SAND-77-0777, Sandia Laboratories, Albuquerque, New Mexico, April 1978.
2. Blake, V.E., Sandia Memo to Miller, L.G., Col. Field Command, Defense Nuclear Agency, "Igloo Access Denial Evaluation Tests (U)", 7/2/74, Confidential, NSI.
3. Duke, G.H., and Plugge, M.M., "Personnel Barriers Using Barbed Wire or Tape", Sandia Laboratories, August 1974.
4. Fite, R.A., "Final Report, Joint Services Perimeter Barrier Penetration Evaluation", USAMERADCO, April 1976.
5. Moore, R.T., "Penetration Tests on J-SIIDS Barriers", NBSIR-73-223.
6. Moore, R.T., "Barrier Penetration Tests", NBSTN-837.

Note: For descriptions of Jet-Axe charges and their applications, see "Jet-Axe Instructors Training Guide", Explosive Technology (P.O. Box KK, Fairfield, California, 94533), CP-R-054.



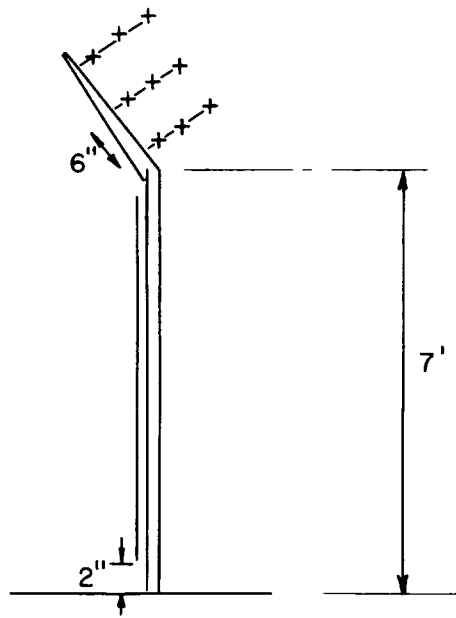
BARRIER 1



DETAIL OF WIRE

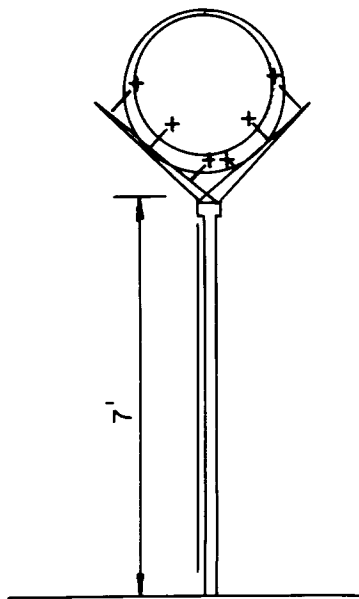
NOT REPRODUCIBLE

BARBED TAPE OBSTACLE



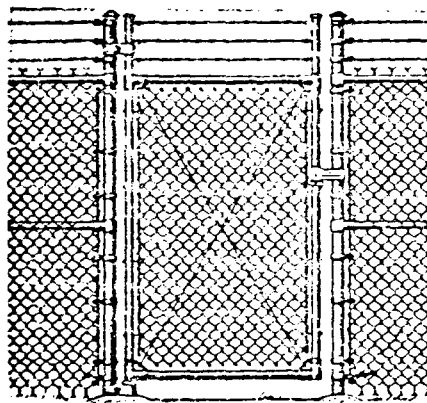
BARRIER 2

7' CHAIN LINK FENCE



BARRIER 3

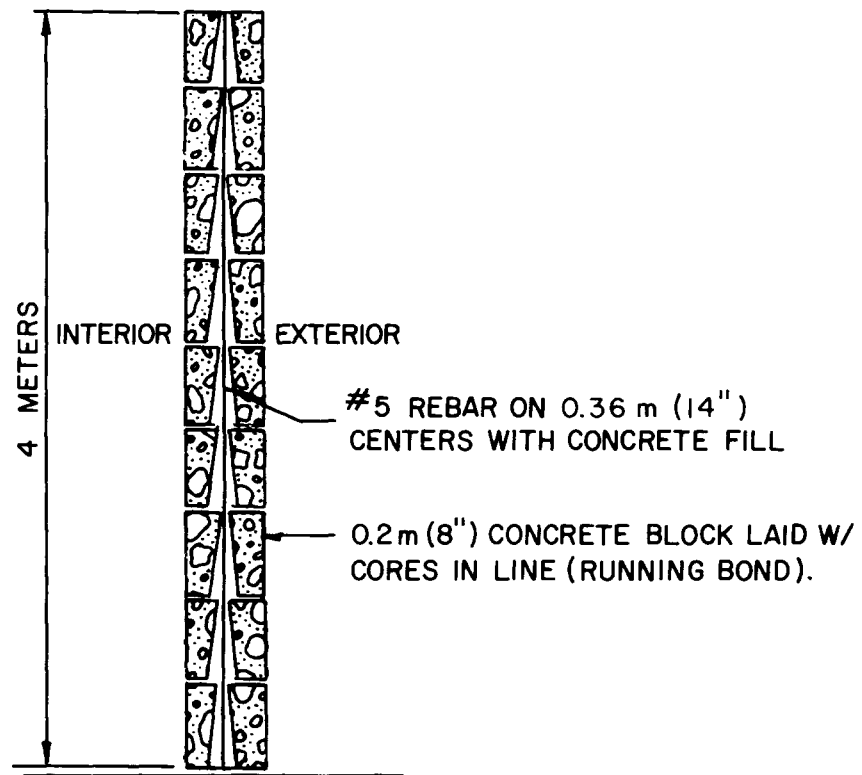
7' CHAIN LINK FENCE WITH CONCERTINA



BARRIER 4

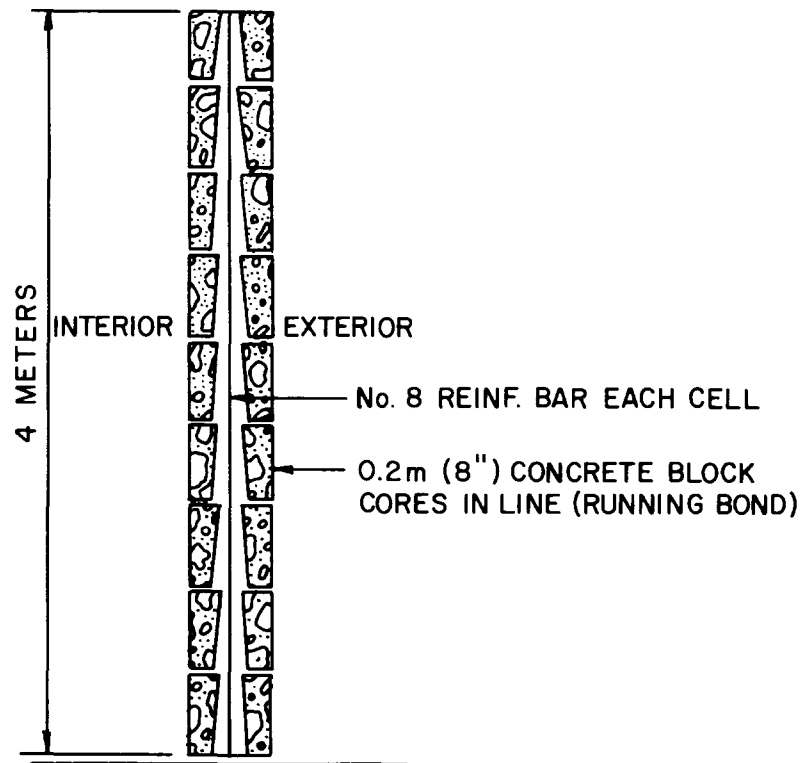
8' SECURITY GATE

NOT REPRODUCIBLE



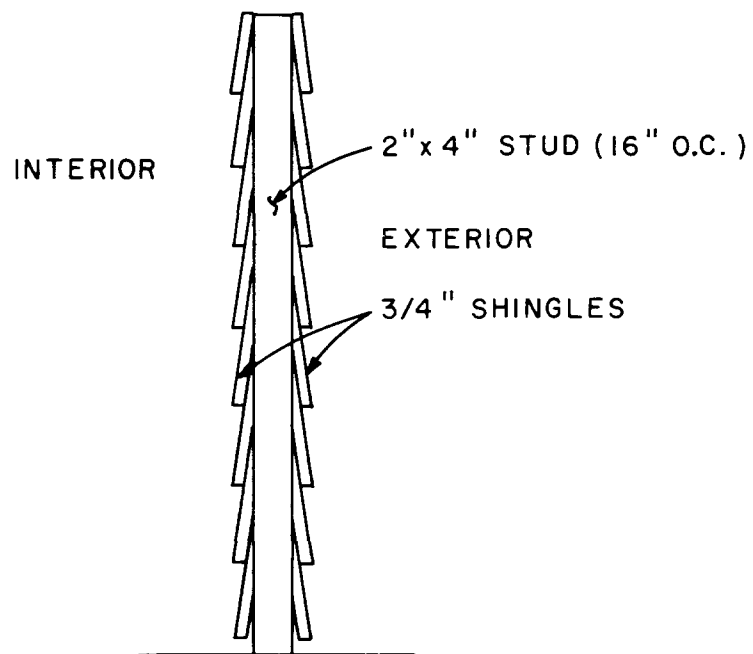
BARRIER 5

8" BLOCK WALL



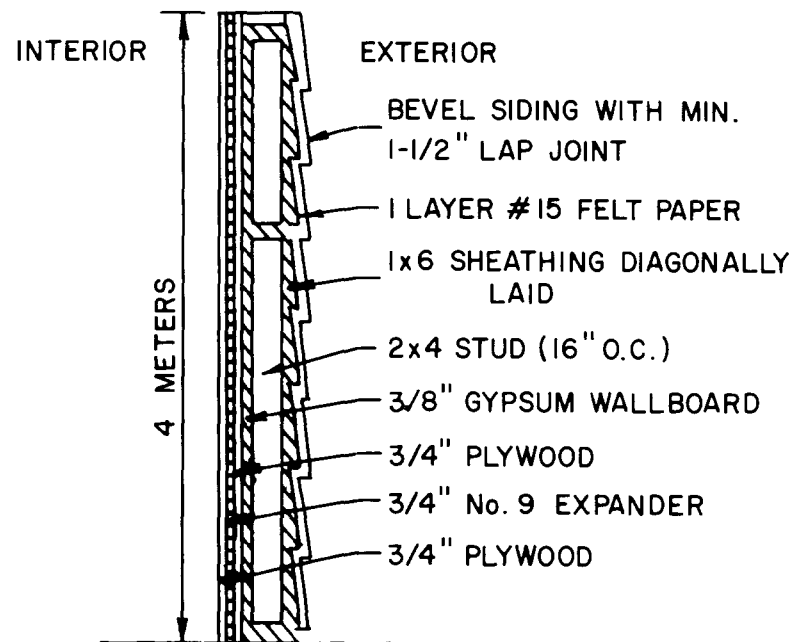
BARRIER 6

8" REINFORCED BLOCK WALL



BARRIER 7  
WOOD FRAME WALL

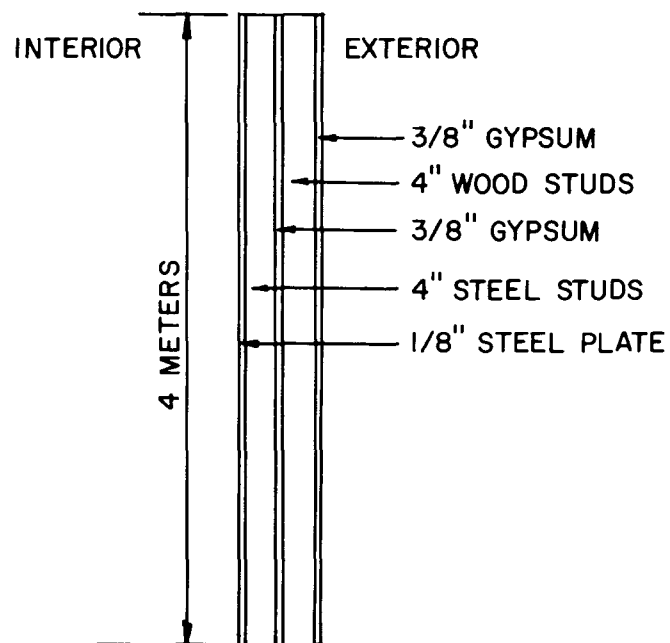




BARRIER 8

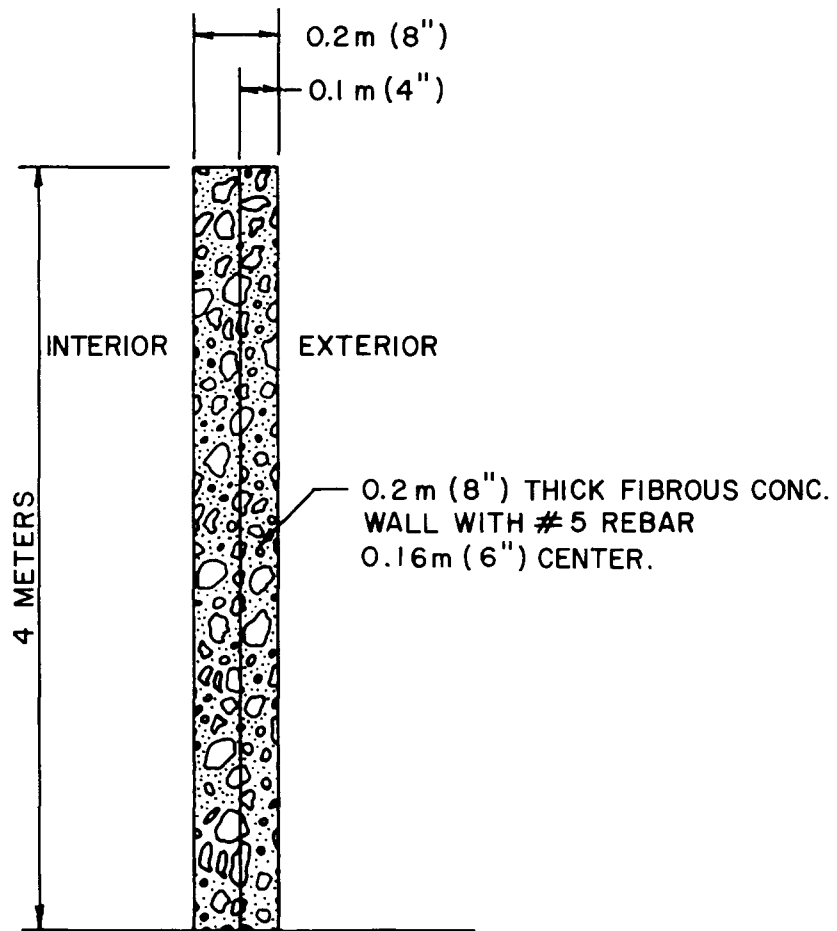
REINFORCED WOOD FRAME WALL

2x4 STUDS COVERED WITH GYPSUM BOARD  
1/8" STEEL PLATE WELDED TO STEEL STUDS



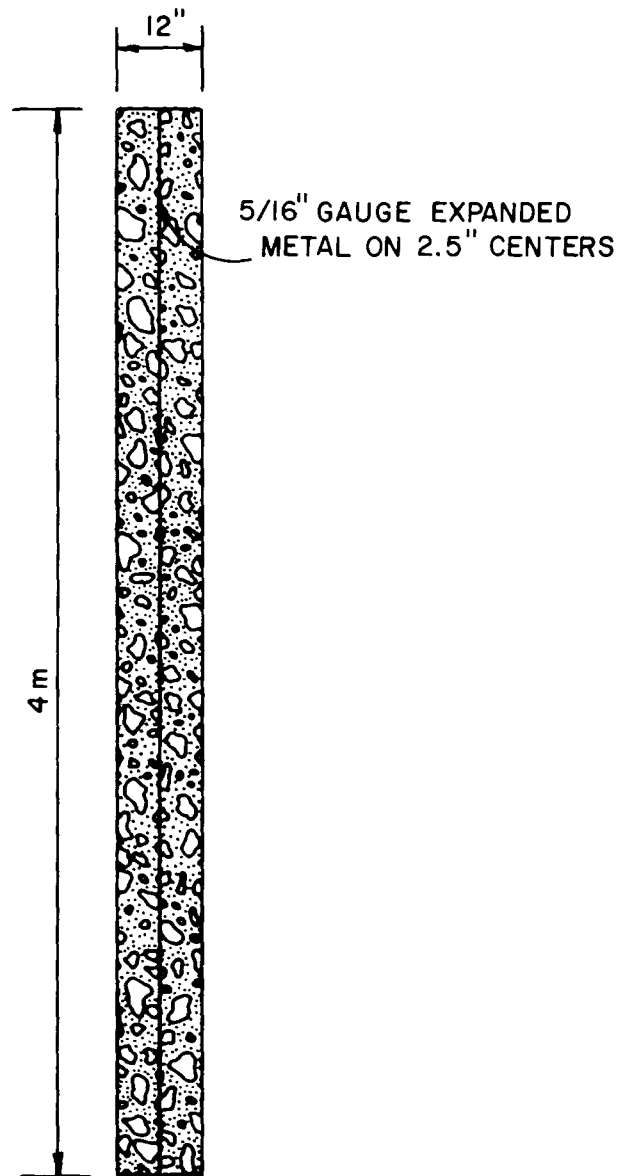
BARRIER 9

STEEL-PLATED WOODEN WALL



BARRIER 10

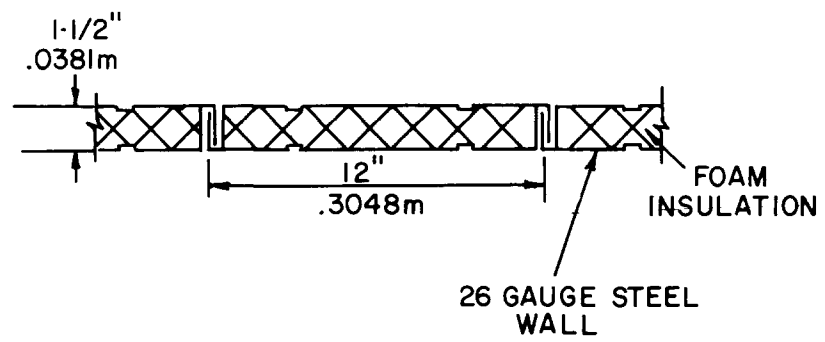
8" REINFORCED CONCRETE WALL



NOT REPRODUCIBLE

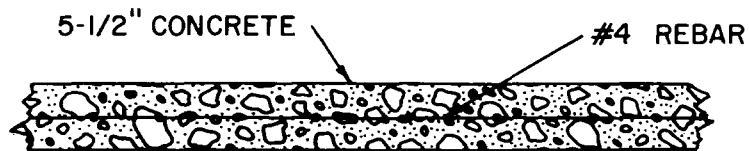
BARRIER 11

12" REINFORCED CONCRETE WALL



BARRIER 13

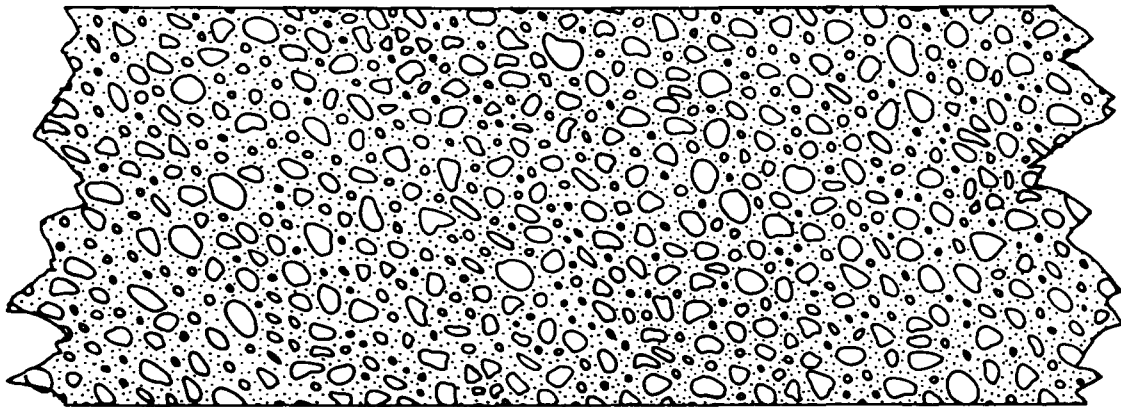
BUTLER-TYPE BUILDING WALL



BARRIER 14

5 1/2" CONCRETE ROOF

24" OF SOIL , CEMENT, WATER, CLOSELY COMPACTED

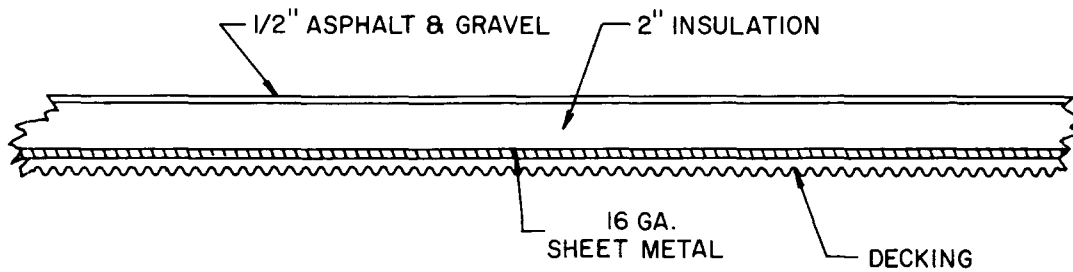


BARRIER 15

NOT REPRODUCIBLE

24" SOIL CEMENT ROOF

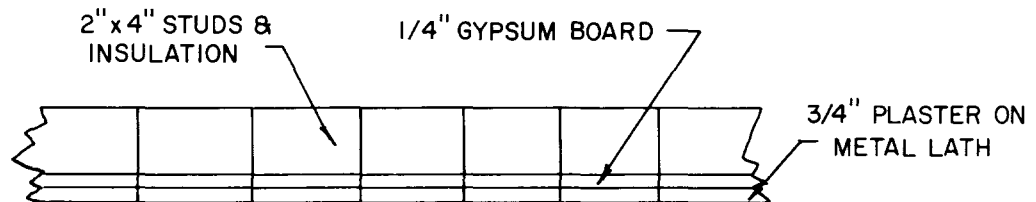
ROOF: 16 GA. SHEET METAL ON RIBBED STEEL DECKING COVERED WITH 2" INSULATION AND 1/2" ASPHALT & GRAVEL



#### BARRIER 16

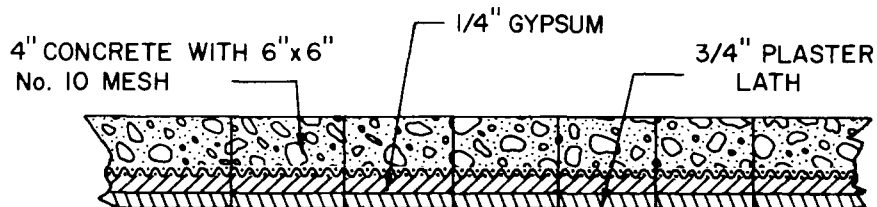
ASPHALT, SHEET METAL, & CONCRETE  
INDUSTRIAL ROOF

3/4" PLASTER ON METAL LATH WITH 1/4" GYPSUM BOARD ATTACHED TO WOOD STUDS WITH 3-1/2" INSULATION BETWEEN STUDS.



#### BARRIER 17

PLASTER - SHEET ROCK CEILING

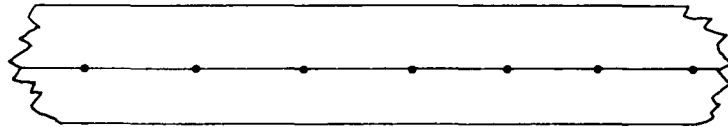


4" CONCRETE WITH 6" x 6" No. 10 MESH  
3/4" PLASTER LATH ATTACHED TO 1/4" GYPSUM BOARD

PLASTER ON CONCRETE CEILING

#### BARRIER 18

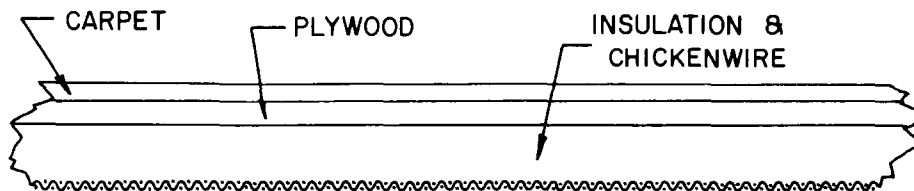
8" CONCRETE REINFORCED WITH No. 4 REBAR ON  
12" x 12" CENTERS



BARRIER 19

8" CONCRETE FLOOR

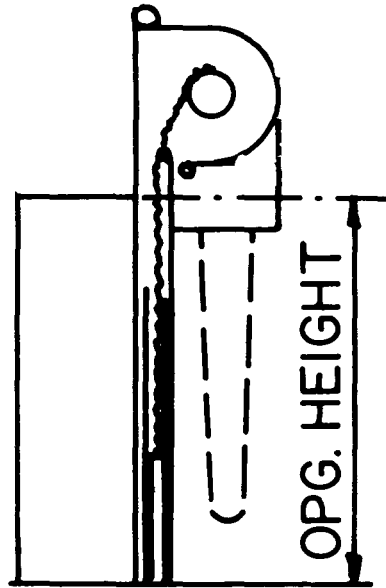
1-1/2" PLYWOOD WITH 3-1/4" INSULATION & CHICKENWIRE COVERED BY  
CARPET



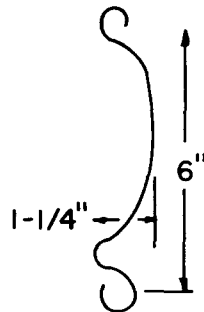
BARRIER 20

PLYWOOD FLOOR





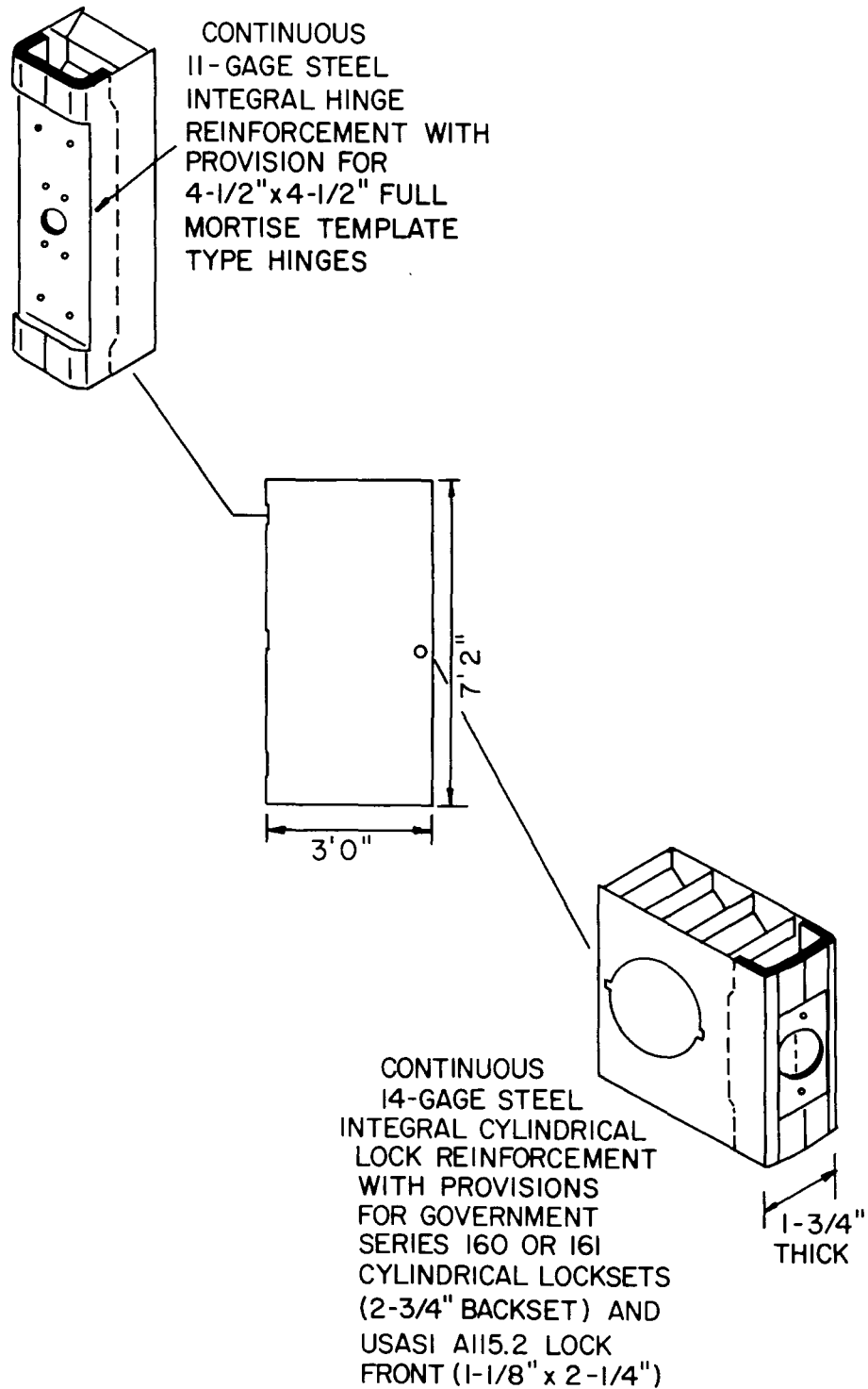
Side view of corrugated door consisting of attached slats drawn around drum at top.

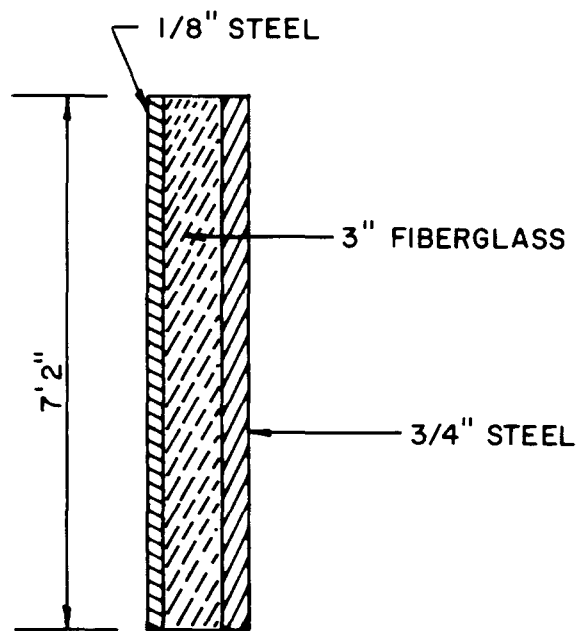


SLAT DETAIL

BARRIER 21

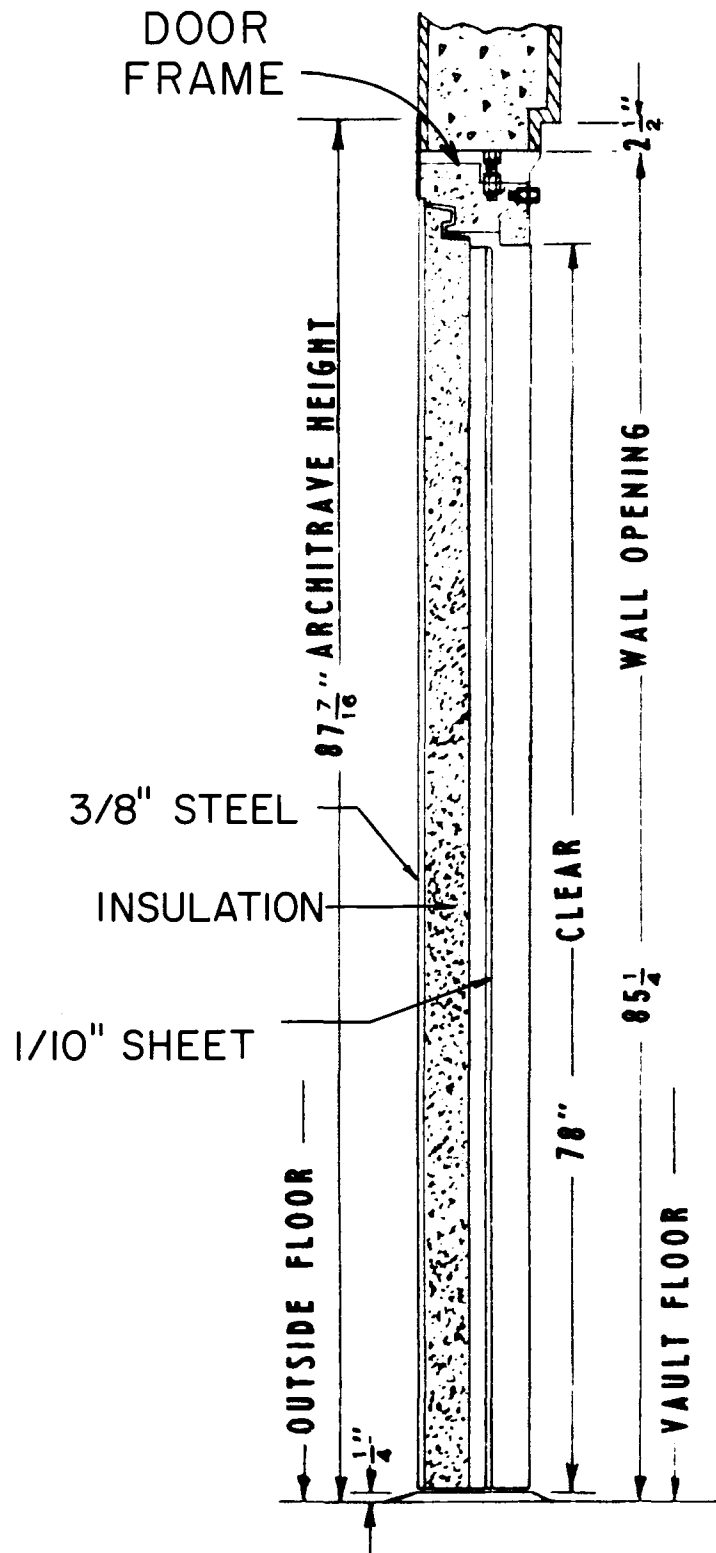
CORRUGATED STEEL ROLLUP VEHICLE DOOR





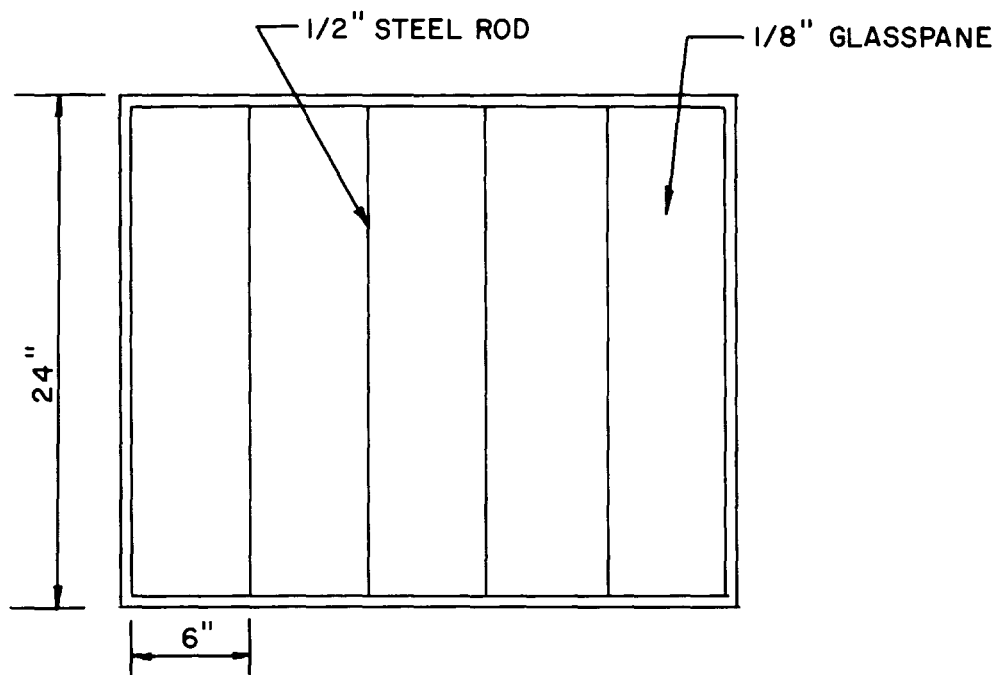
BARRIER 23

SUBSTANTIAL STEEL DOOR



BARRIER 24  
GSA CLASS 6 VAULT DOOR

## WINDOW WITH 1/2" STEEL ROD

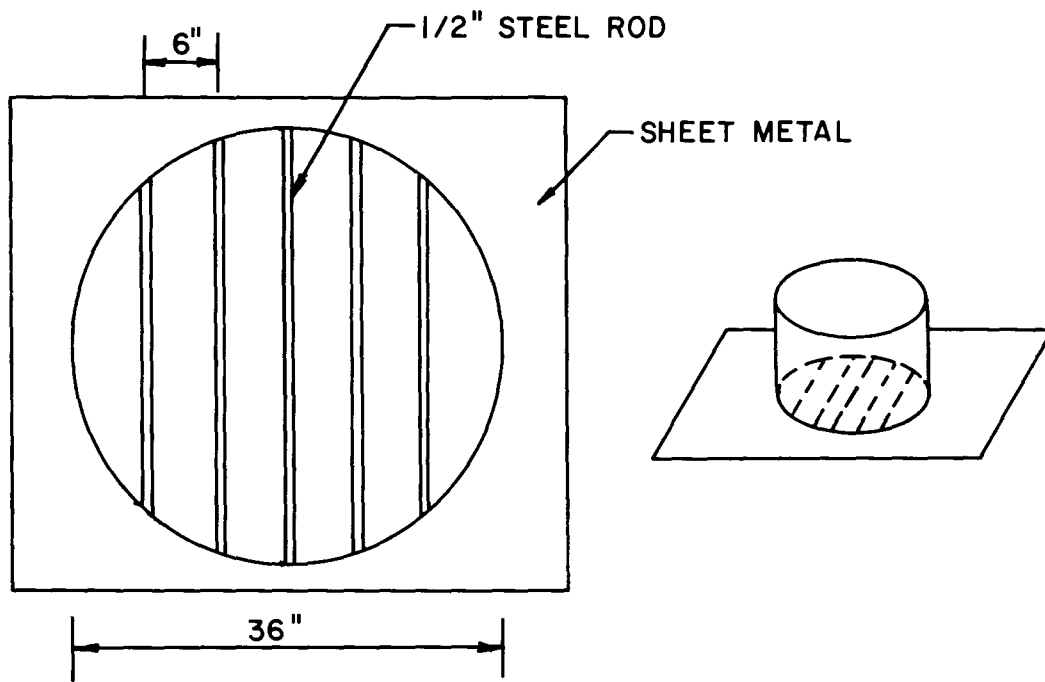


BARRIER 27

EXPANDED STEEL MESH COVERED WINDOW

## ROOF EXHAUST PORT

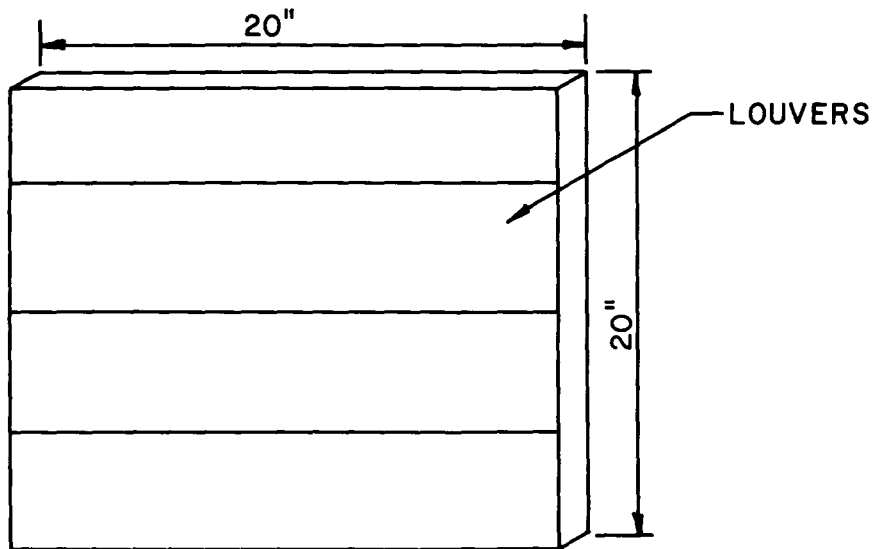
46



BARRIER 29

ROOF EXHAUST - REINFORCED

## AIR CONDITIONING EXHAUST PORT



BARRIER 30

LOUVERED SHEET METAL PORT