The objective of the Experimental Testing Task is to experimen determine the characteristics of the ignition of flammable vapoı fired water heaters.

- Selected incident scenarios to be evaluated
- Conditions for the ignition of flammable vapors understood and c

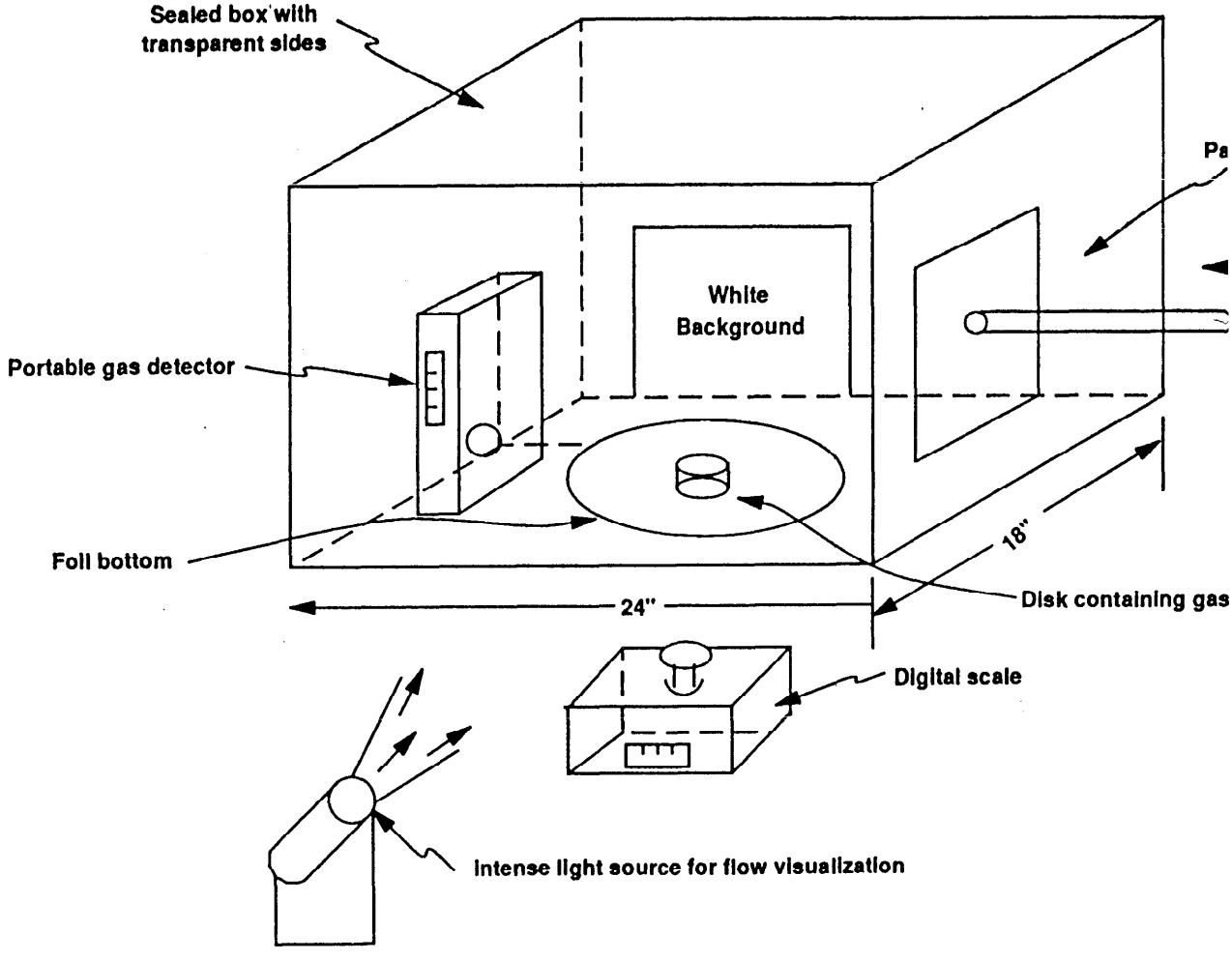
[redacted]

Small-scale (bench-top) tests have been completed to illustrate principles and verify analytical model.

- Evaporation rate measured to verify liquid model.
- Shadowgraph method demonstrates effect of motion.
- Portable gas detector verifies vapor dispersion model.

Experimental Testing Task Small Scale Test

The small scale test facility demonstrates evaporation rate, vap dispersion, and the effect of vapor movement.

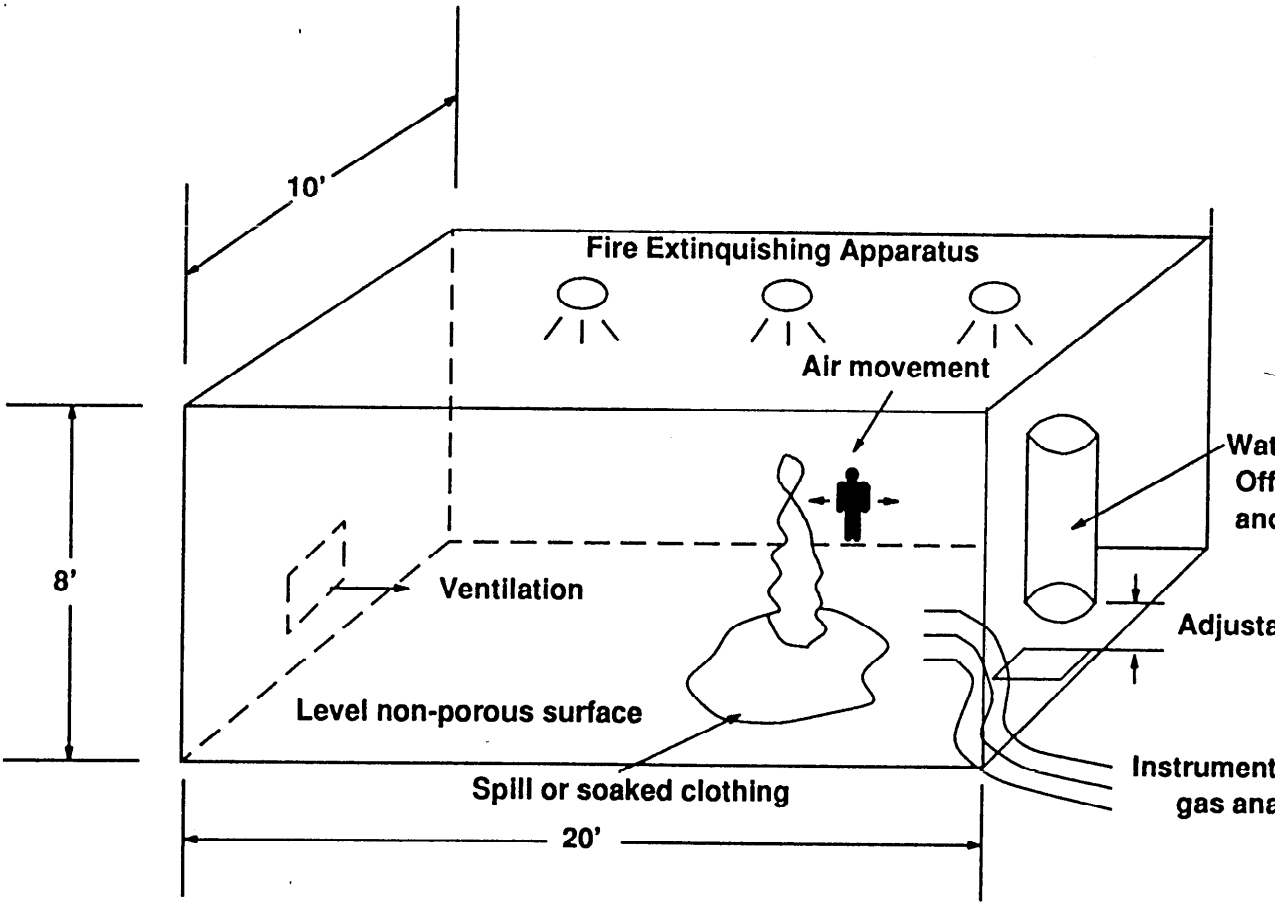


Arthur D Little

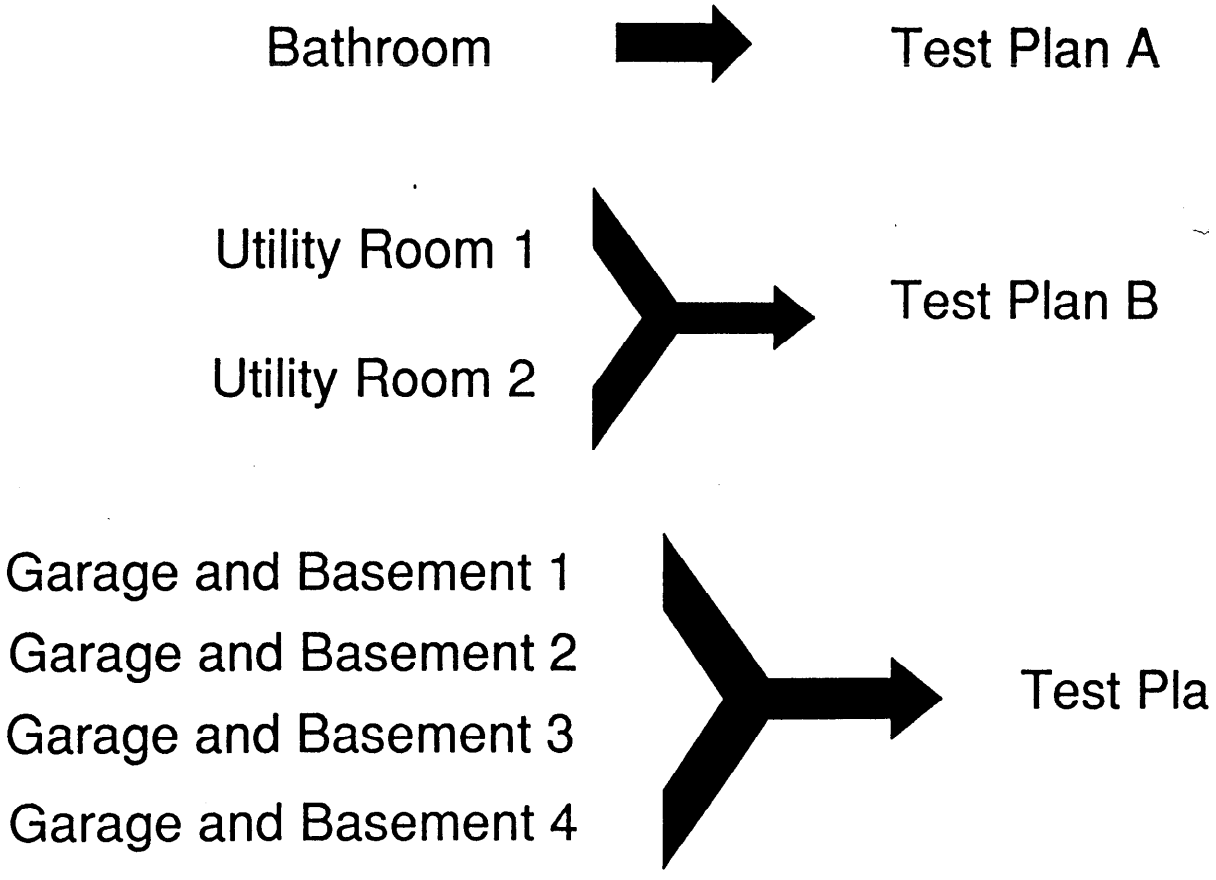
Instrumentation will document the temperature, flow and vapo composition necessary to understand conditions for vapor ign

- Thermocouples will measure temperature
- Anemometry will detect natural air movement into the burner ar rates
- Vapor composition will be determined by four methods:
  - flame ionization detector (FID) readings will be multiplexed f detection of flammable limit
  - portable gas detector as back-up to FID
  - gas chromatography for batch determination of sample cons
- Vapor front to be visualized using shadowgraph

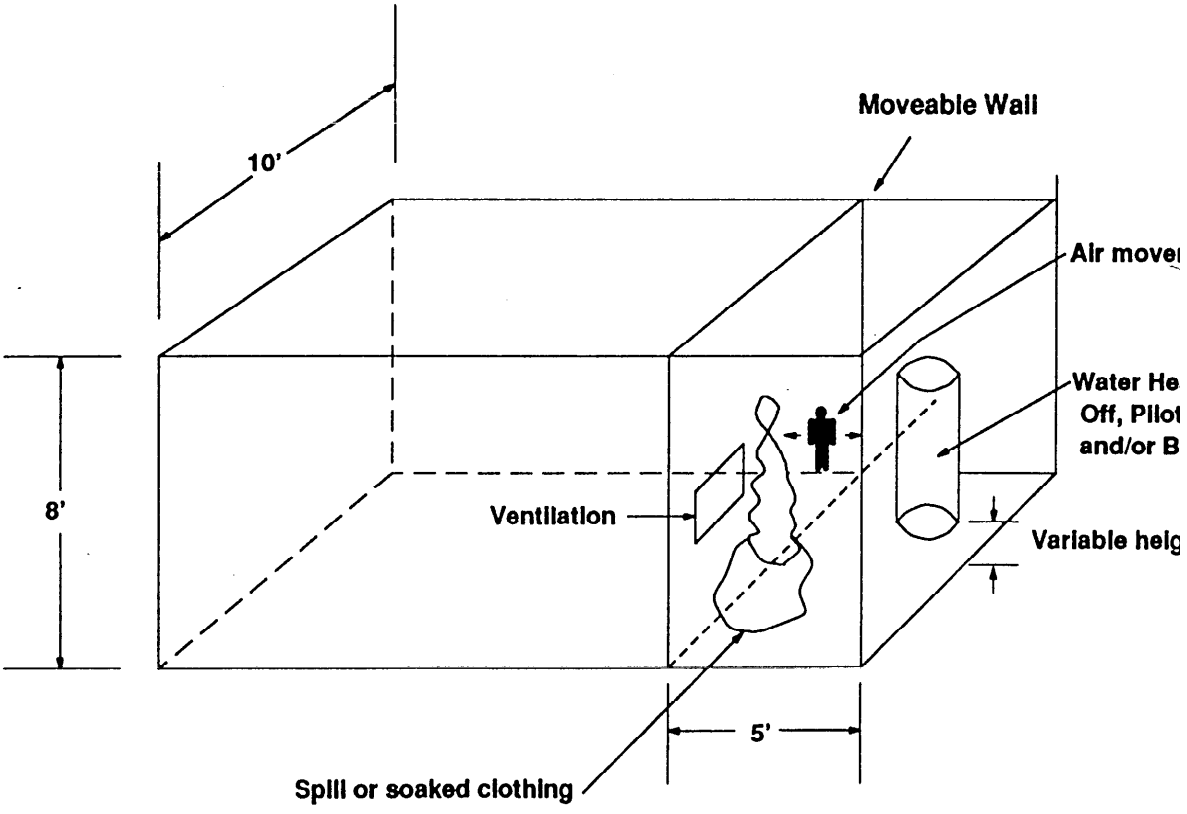
The Full-Scale Test Facility allows for flexibility needed to imp test plans.



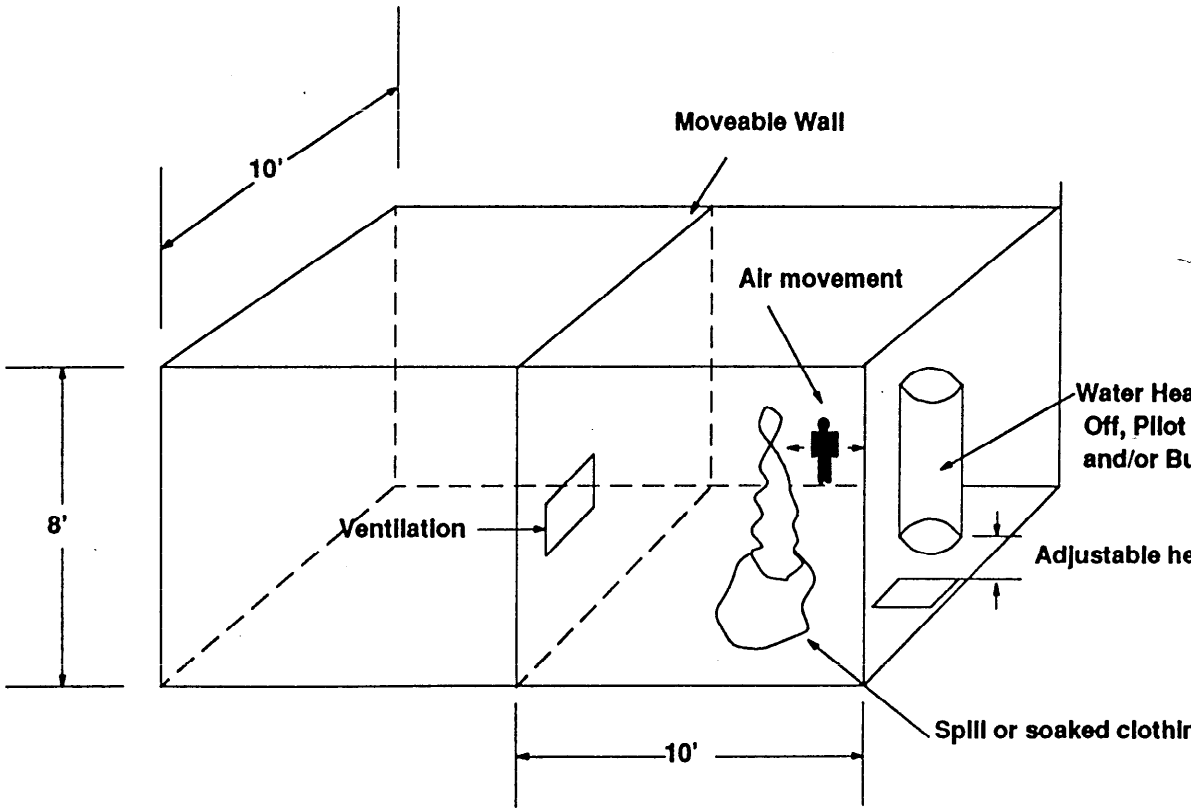
Scenarios from the Data Collection and Analysis Task have de
Plan for Experimental Testing. The seven scenarios can be
experimentally modeled with three test plans.



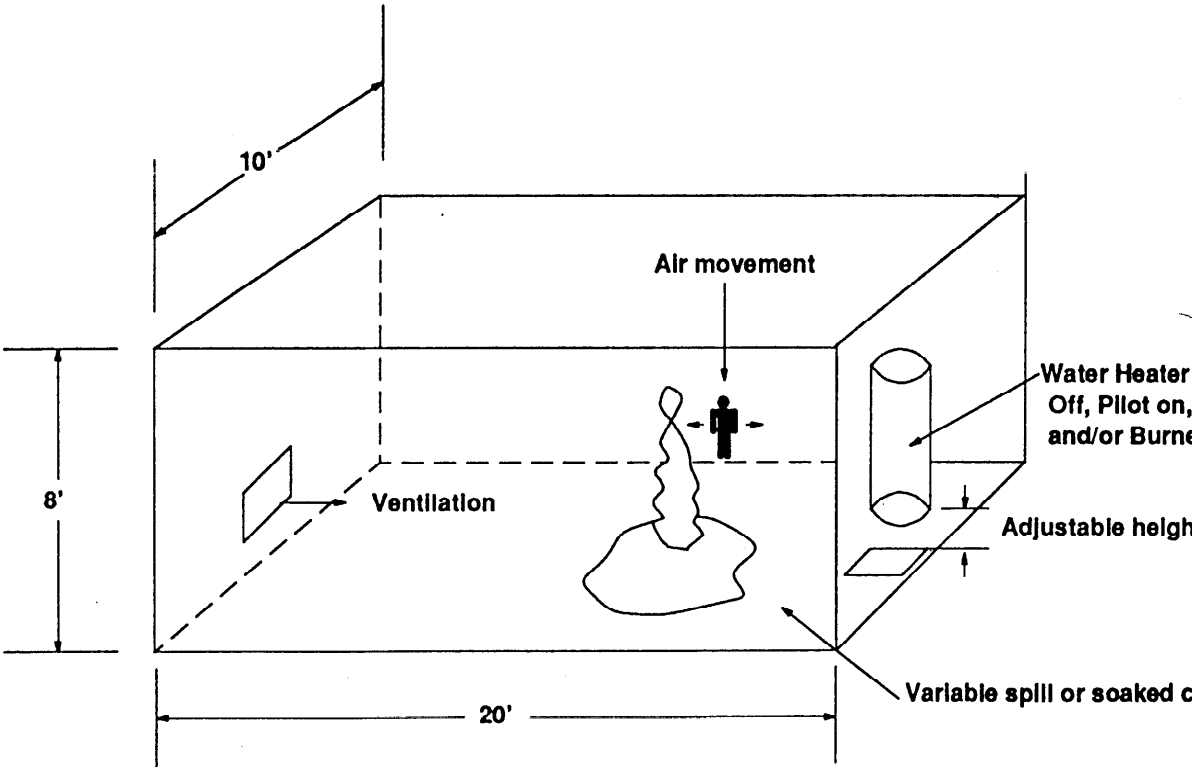
Test Plan A models a bathroom with ignition from a spill or so clothing.



Test Plan B models a utility room with ignition from a spill or s clothing.



Test Plan C models a garage with ignition from a spill or soake



The preliminary test matrix includes the following variable con

- Fluid
  - gasoline spill of varying amounts
  - stand of clothing saturated with gasoline
- Variable ventilation
- Simulated body movement
- Variable water heater height
- Variable operation of water heater
  - off with simulated draft
  - pilot only on
  - fully ignited

A preliminary matrix has been developed for the experimental

Test #	Plan	Room Size	Soak/Spill		Ventilation		Movement		WH Height		V
			Soak	Spill	Low	High	Yes	No	Level	18"	O
1	C	Large		L	X			X	X		X
2				L	X			X	X		
3				L		X		X	X		X
4				L		X		X	X		
5				L		X		X			
6				L	X					X	X
7				L				X		X	
8				L	X			X		X	
9				L		X		X		X	X
10				L		X		X		X	
11				L		X		X		X	
12				V	X			X	X		X
13				V	X			X	X		
14				V	X			X		X	X
15				V	X			X		X	

Experimental Testing Task Test Plan (continued)

Test #	Plan	Room Size	Soak/Spill		Ventilation		Movement		WH Height		W
			Soak	Spill	Low	High	Yes	No	Level	18"	Of
16				V	X			X		X	
17			X		X		X		X		X
18			X		X		X		X		
19			X		X		X		X		
20			X		X		X			X	X
21			X		X		X			X	
22			X		X		X			X	
23	B	Med		S	X				X		X
24				S				X	X		
25					X		X		X		X
26					X		X		X		
27			X		X		X		X		
28	A	Small		S	X			X	X		X
29				S	X			X	X		
30				S	X			X	X		
31			X		X		X		X		X
32			X		X		X		X		
33			X		X		X		X		

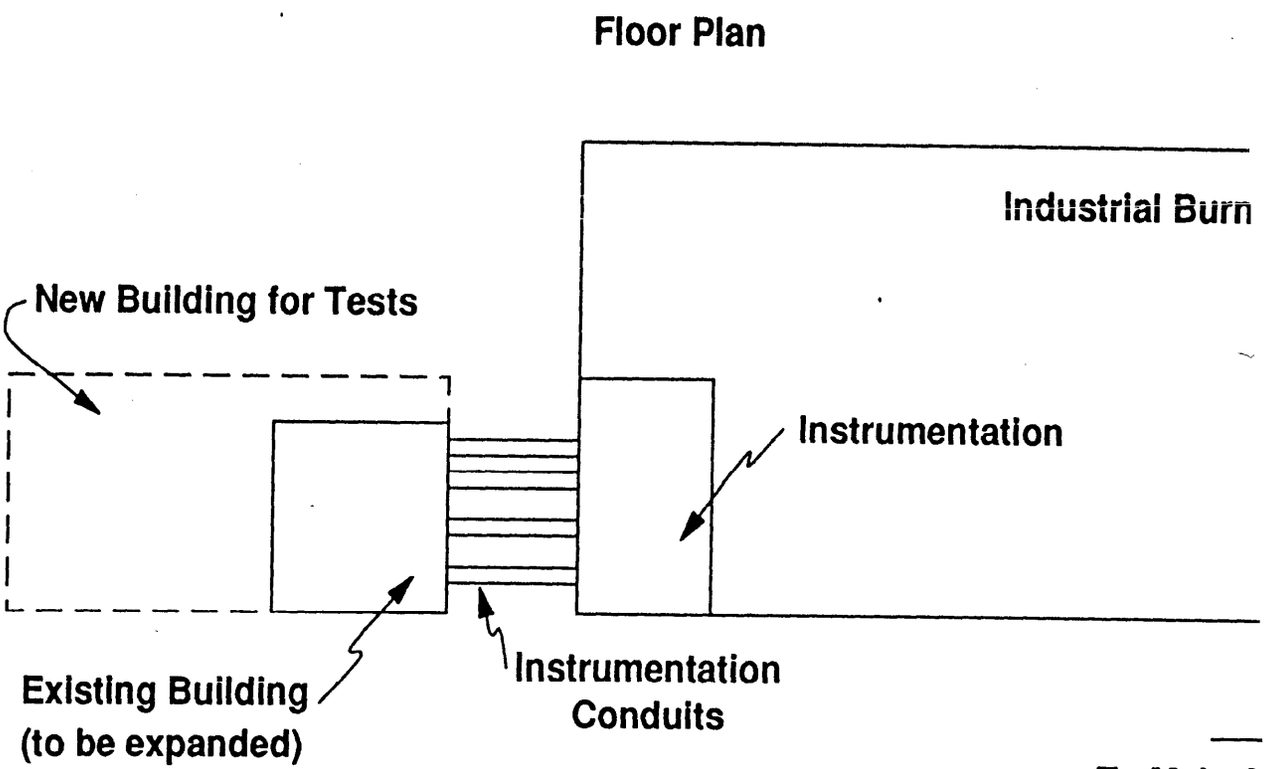
The American Gas Association Laboratories were chosen for location.

- A purchase order is being issued to use the facilities.
- Instrumentation is being calibrated.
- Tests will begin before the end of February and last approximat weeks

[redacted]

Experimental Testing Task Site Selection

A building is being modified at the American Gas Association Laboratories to accommodate testing.



Arthur D Little

[redacted]

Experimental Testing Task Test Status

The preliminary Experimental Plan is completed, and a test sit selected. The following tasks remain:

- Execute test plan
- Coordinate with analytical modeling to understand and define cc dispersion and ignition of flammable vapors
- Summarize results

[redacted]

The purpose of this study is to investigate and characteriz posed by the ignition of flammable vapors. To accomplish divided the effort into three tasks.

Task	Ob
1. Data Collection and Analysis ***Complete***	Determine t characteristi incidents
2. Analytical and Experimental Testing ***Underway***	Analytically experimenta scenarios d in Task 1
3. Analysis of Consumer and Installer Activities ***Pending***	Determine i procedures effectivenes labels and i

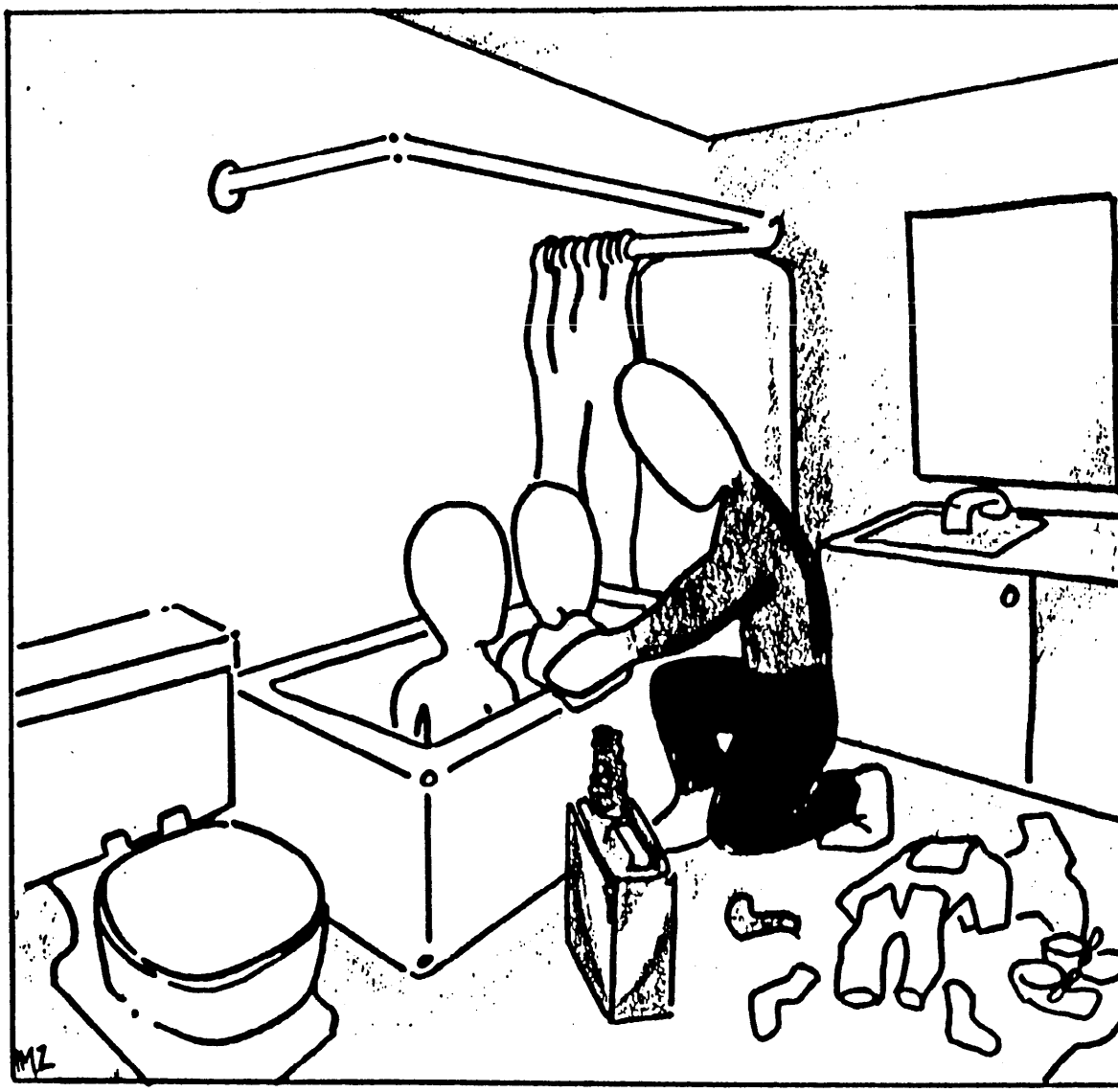
The objective of this task was to develop typical incident sc involving the ignition of flammable vapors by gas fired wate accomplish this, numerous sources of data were used.

- Detailed incident databases (CPSC IDI's, NFPA FIDO, CPS
- National and state fire incident databases (NFIRS, CFIRS, C
- Interviews (attorneys, expert witnesses, government agencie
- Published reports (Calspan reports, Gauthier & Murphy, LA Study)

Review and analysis of these data indicates that seven sce represent 80 - 90% of the incidents of flammable vapor igni fired water heaters.

- 1 Bathroom Scenario
- 2 Utility Room Scenarios
- 3 Garage and Basement Scenarios
- 1 Garage Scenario

Bathroom Scenario



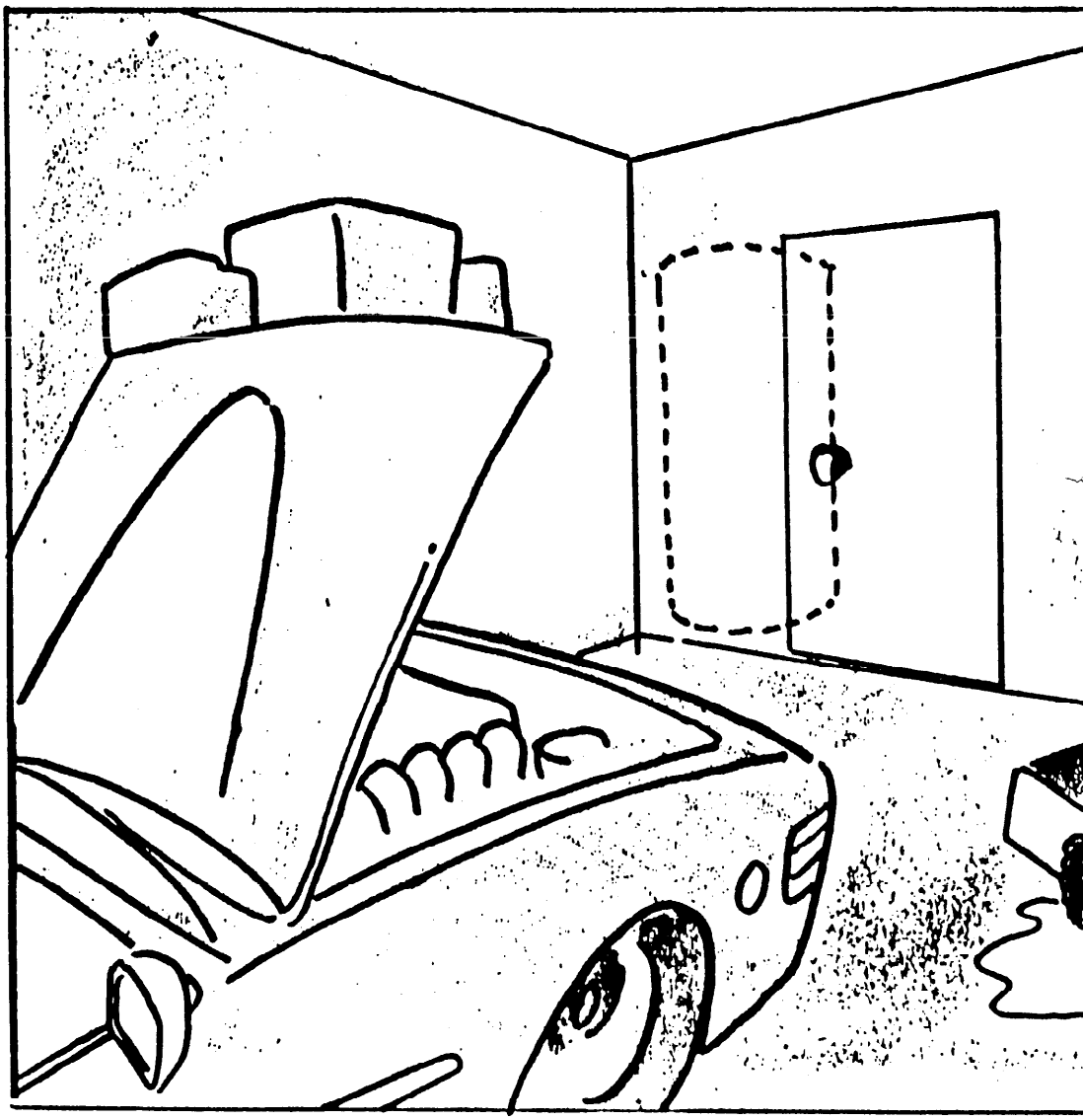
Bathroom Scenario: Although bathroom installation of fuel heaters is prohibited, flammable vapor ignition by water hea bathrooms does occur, and the injury ratio is more than tw average.

A common scenario involves a person becoming "soaked" with some activity such as cleaning parts, car repair or fueling operat person goes to the bathroom and removes his clothing to take a shower. Upon exiting the tub, there is a flash fire.

A similar scenario involves children becoming covered in paint a brought into the bathroom to have the material removed using g children are usually in the tub with a guardian using a gasoline s clean them. In this case there is also water being used for rinsi

Spillage of gasoline was not reported as a contributing factor in reviewed cases.

Utility Room Scenario 1: Spill outside of room



Utility Room Scenario 1: Spill outside of room

A common scenario involves a person using gasoline outside of for some purpose such as cleaning or fueling. The fuel is spilled from evaporation of the puddle or vapors from gasoline use trave heater located on the utility room. There is no activity or movem direct vicinity of the water heater. There is possible operation of equipment in the room at the time of the release.

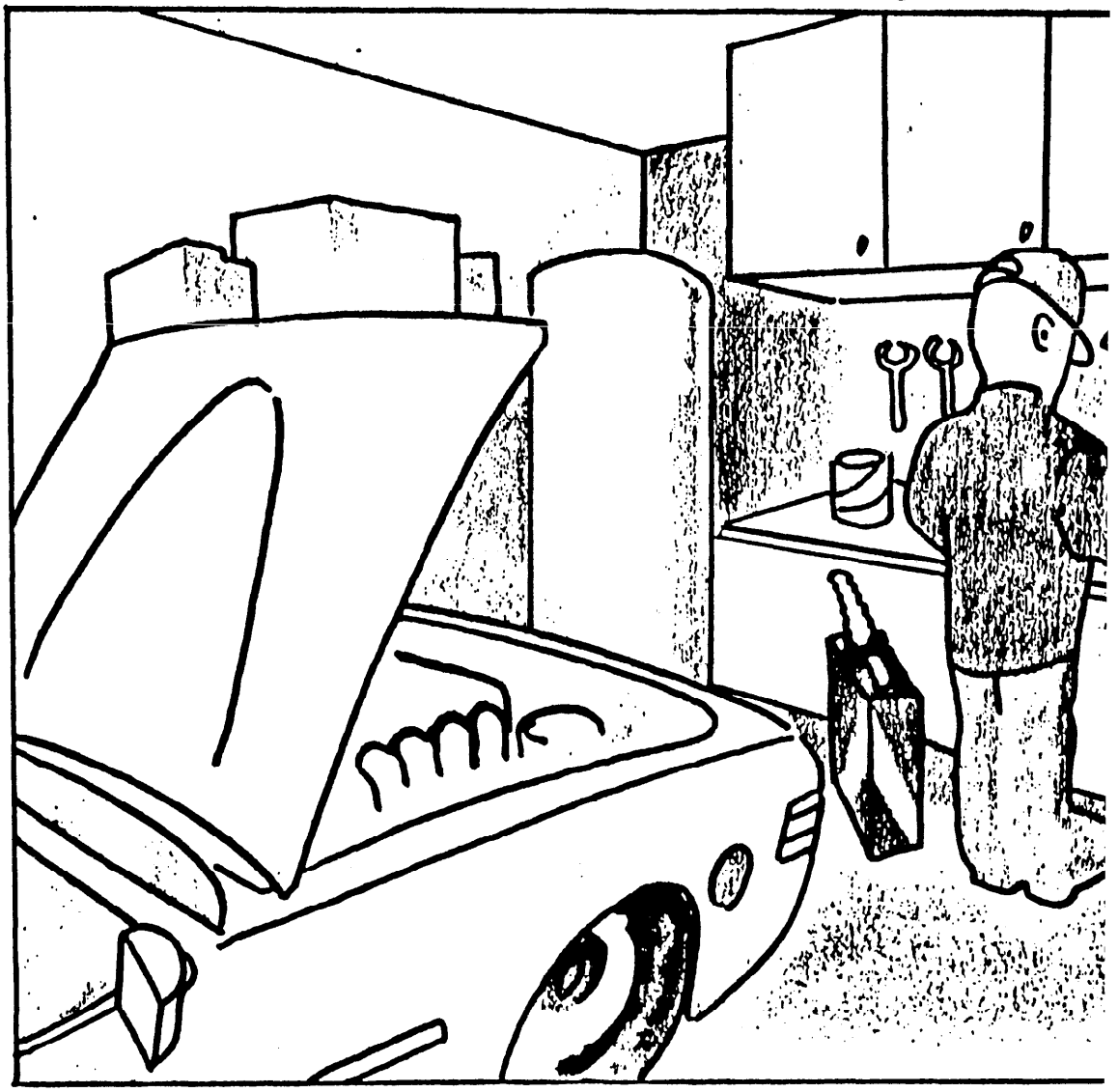
Utility Room Scenario 2: Spill inside of room

Utility Room Scenario 2: Spill inside of room

A common scenario involves a person using gasoline inside of t for some purpose such as cleaning or fueling. The fuel is either vapors from evaporation of the puddle or vapors from gasoline u water heater located in the utility room. There is activity or mov direct vicinity of the water heater. Possible operation of other ec room at the time of the release.

A version of this scenario involves children playing in the utility r spilling a large amount of gasoline (1-5 gallons) in the vicinity of heater.

Garage and Basement Scenario 1: Gasoline Usage



Garage and Basement Scenario 1: Gasoline Usage

A common scenario involves a person using gasoline inside a garage for some purpose such as parts or brush cleaning, aut removal of stains/rubber backed carpet from the floor. The vap gasoline use travel to the water heater located in the vicinity. or movement in the direct vicinity of the water heater.

Only a small amount of gasoline used at any one time.

Analysis of the data gathered in the Data Collection and Ana has provided insight into issues which are being addressed Analytical and Experimental Testing Task.

The objective of the Analytical Modeling Task is to provide insight into key parameters for testing:

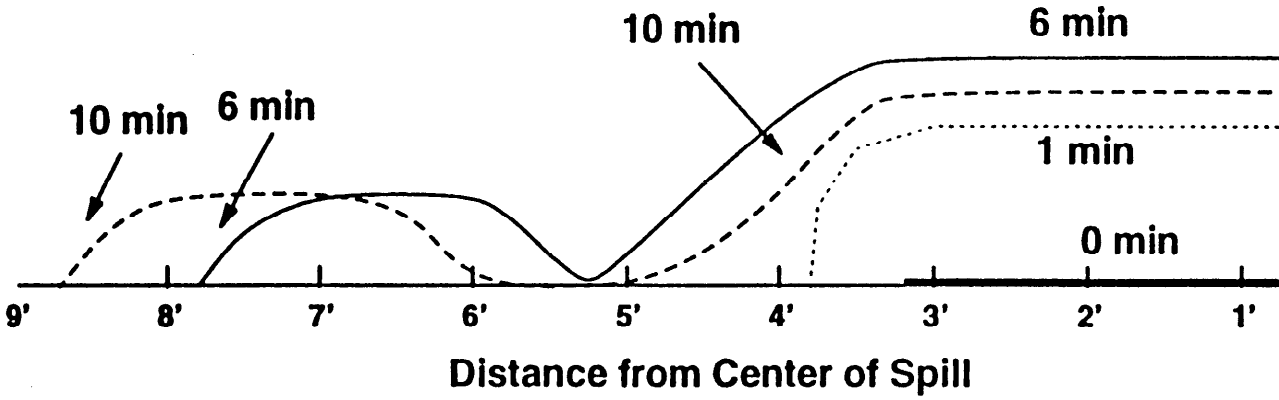
- Verification and/or identification of scenario patterns
- Assess parameter sensitivity for experimental tests
- Provide theoretically based extension of experimental result

Modeling results indicate the importance of the heavy gas l gasoline spills.

- There is little mixing in the vertical direction, and thus a vapc generated that hugs the ground
- The initial rate of horizontal spreading is significant and is de difference between the vapor and air density
- Vapor rises when disturbed by movement and builds up aga obstructions

The complete, 24 component dispersion model indicat horizontal movement of the vapor layer.

Lower Flammable Limit Profiles Quiescent Conditions

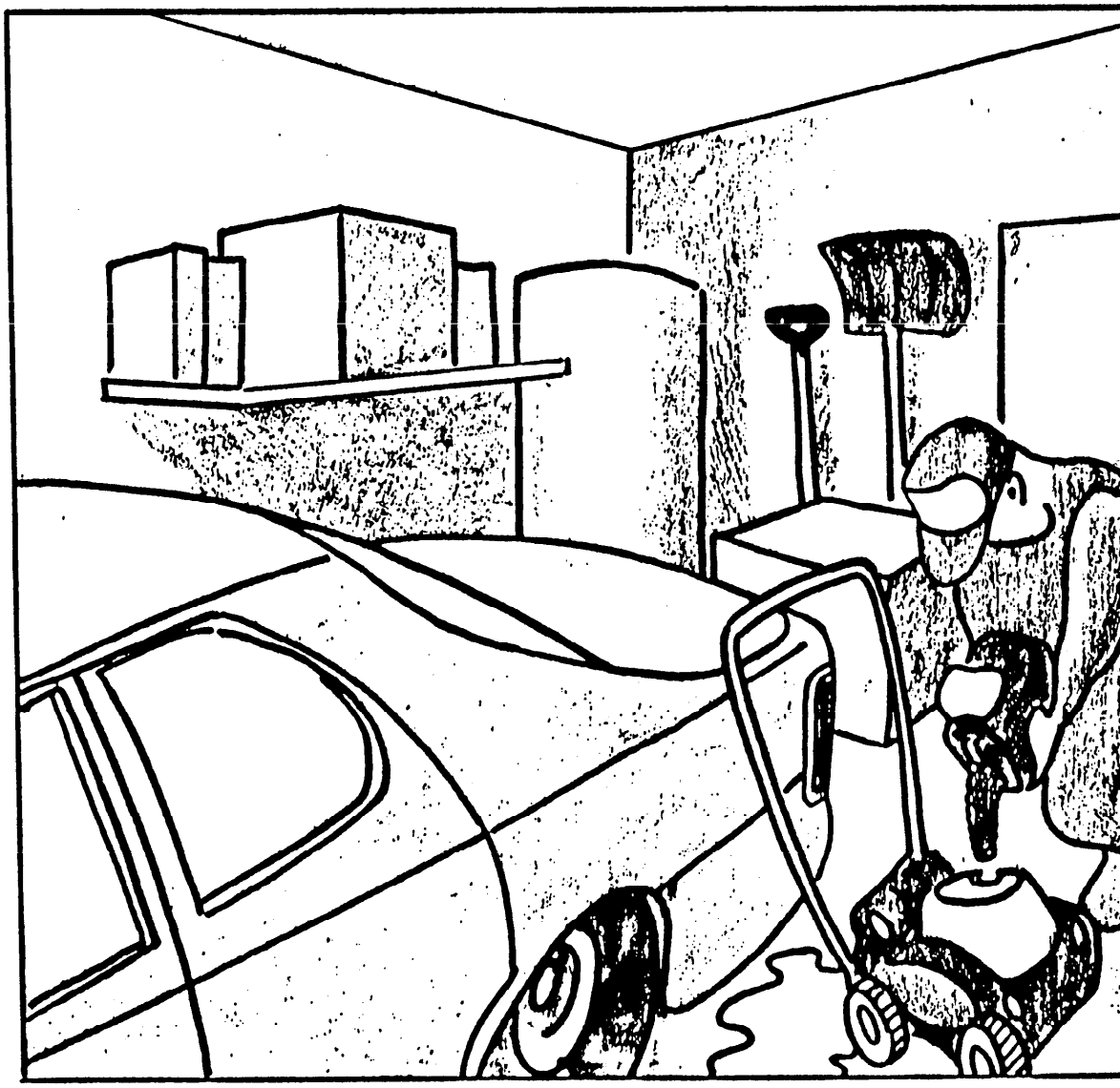


Garage and Basement Scenario 1: Gasoline Usage

A common scenario involves a person using gasoline inside a garage for some purpose such as parts or brush cleaning, auto removal of stains/rubber backed carpet from the floor. The vapo gasoline use travel to the water heater located in the vicinity. T or movement in the direct vicinity of the water heater.

Only a small amount of gasoline used at any one time.

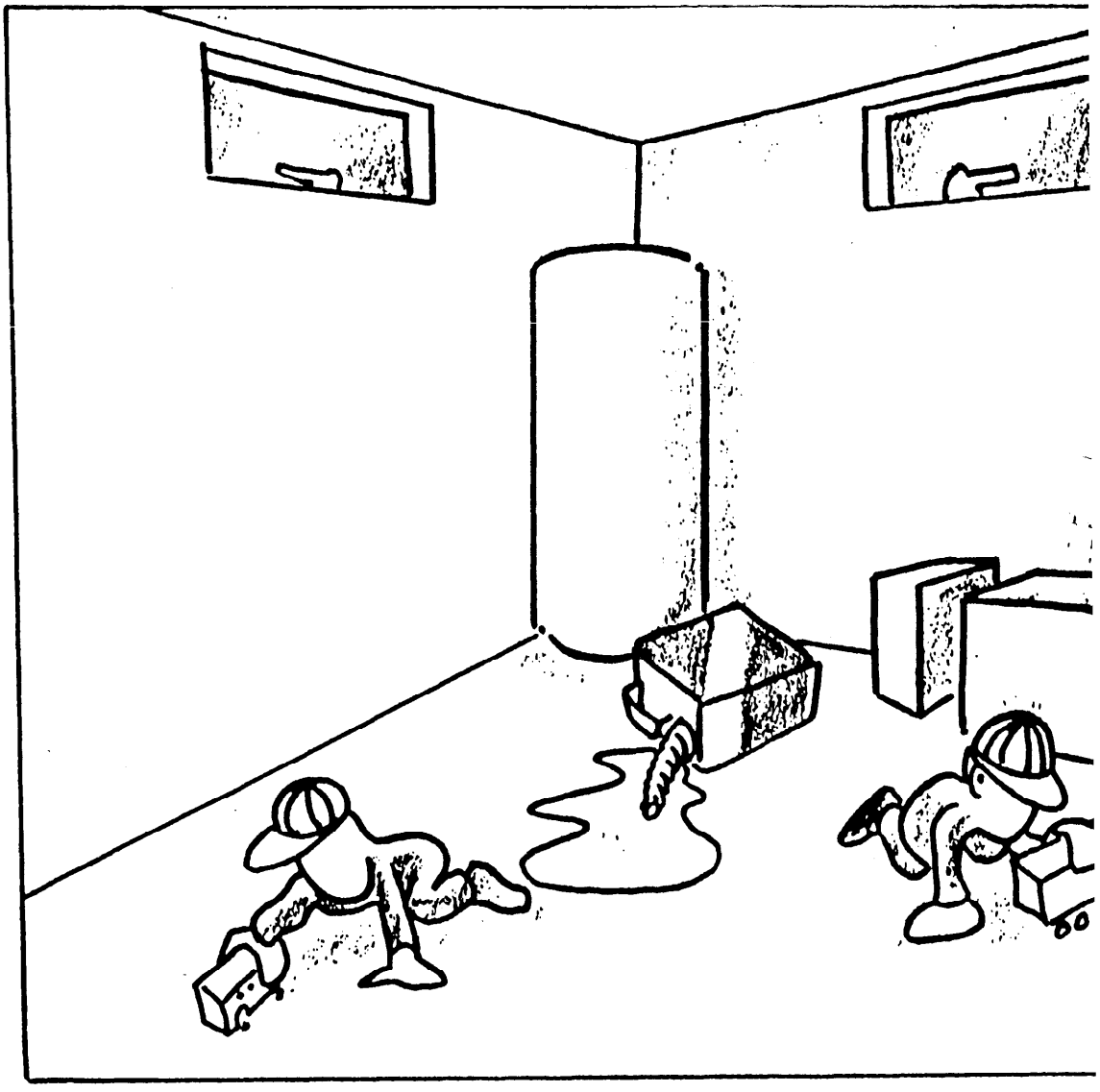
Garage and Basement Scenario 2: Refueling



Garage and Basement Scenario 2: Refueling

A common scenario involves a person refueling a piece of equi
uses gasoline such as a lawn mover, weed wacker or motorcyc
tank is accidentally overfilled or the opening is missed. This re
moderate quantity of gasoline being spilled on the floor. The va
gasoline use travel to the water heater located in the vicinity. T
or movement in the direct vicinity of the water heater. (Example
from just refueling and no spillage were not identified directly in

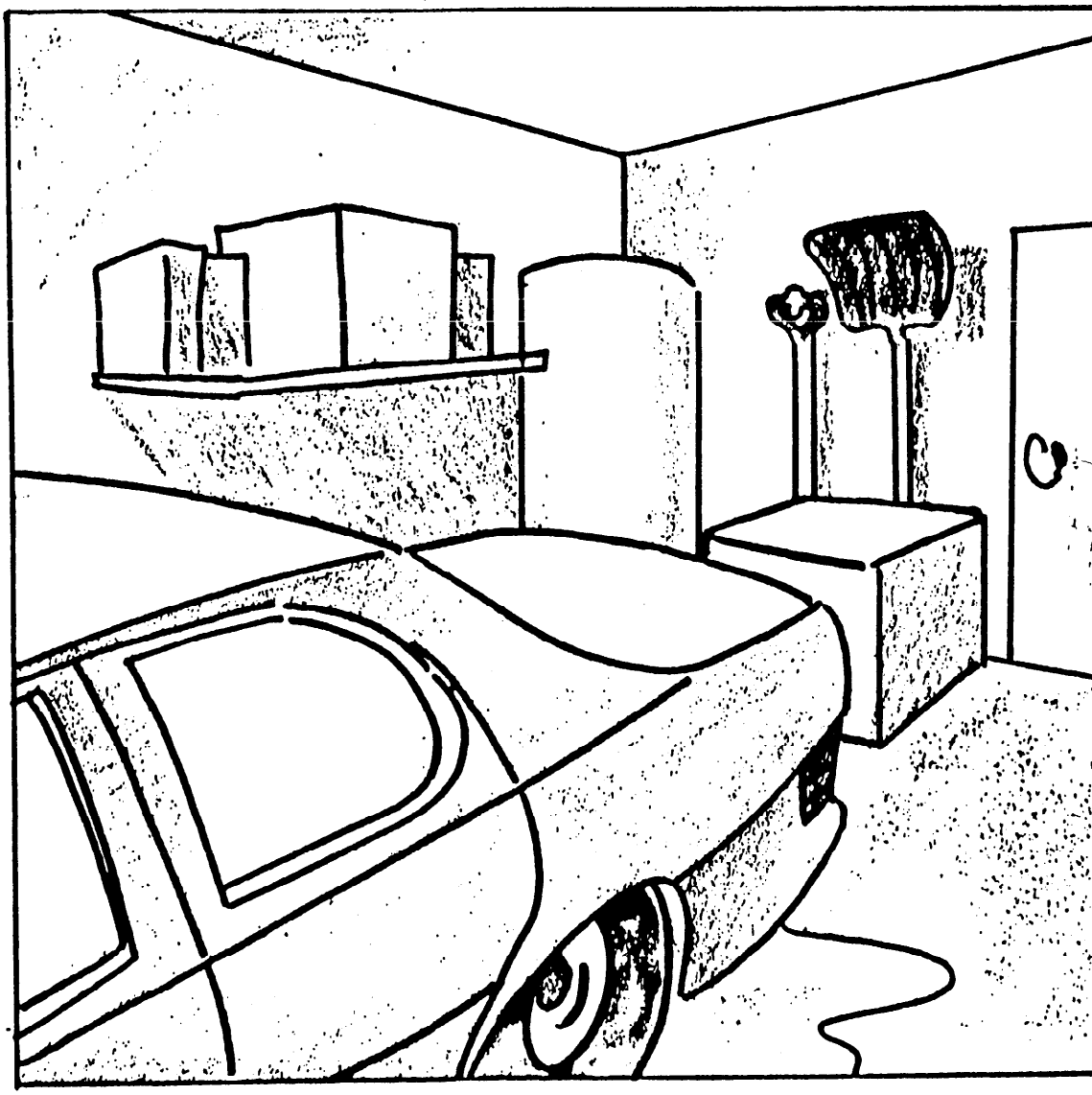
Garage and Basement Scenario 3: Children Playing



Garage and Basement Scenario 3: Children Playing

A common scenario involves children playing in the garage or ba
tipping over a container of gasoline. They generally knock the ca
allowing the container to empty at a steady rate, or they attempt t
with the container of gasoline. In both scenarios, there is a large
gasoline spilled near the water heater and activity.

Garage Scenario 1: Leakage



Garage Scenario 1: Leakage

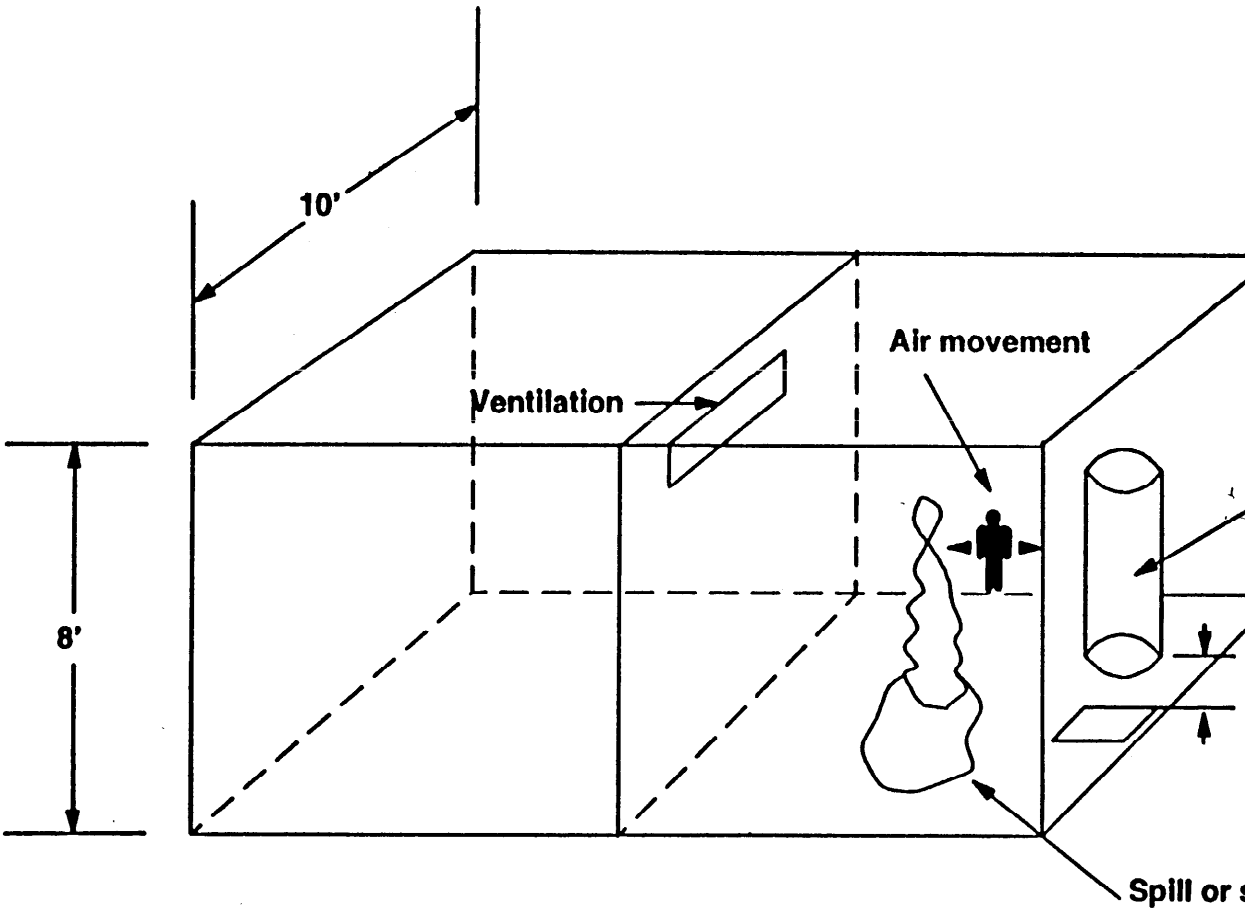
A common scenario involves the slow leak of gasoline from the f vehicle stored in the garage. The rate of gasoline loss is relative gasoline vaporizes and steadily builds up a flammable concentra until ignited by the water heater.

Experimental Testing Task Objective

The objective of the Experimental Testing Task is to experim determine the characteristics of the ignition of flammable va fired water heaters.

- Test and evaluate selected incident scenarios
- Understand conditions necessary for the ignition of flammabl

The test facility is designed to model a variety of acci scenarios.



Results of Experimental Tests

1. Water heater on the floor will ignite flammable vapor under th conditions:

   - 1 gallon spill of gasoline
   - Small or large room
   - Spill location anywhere in room
   - Pilot or main burner