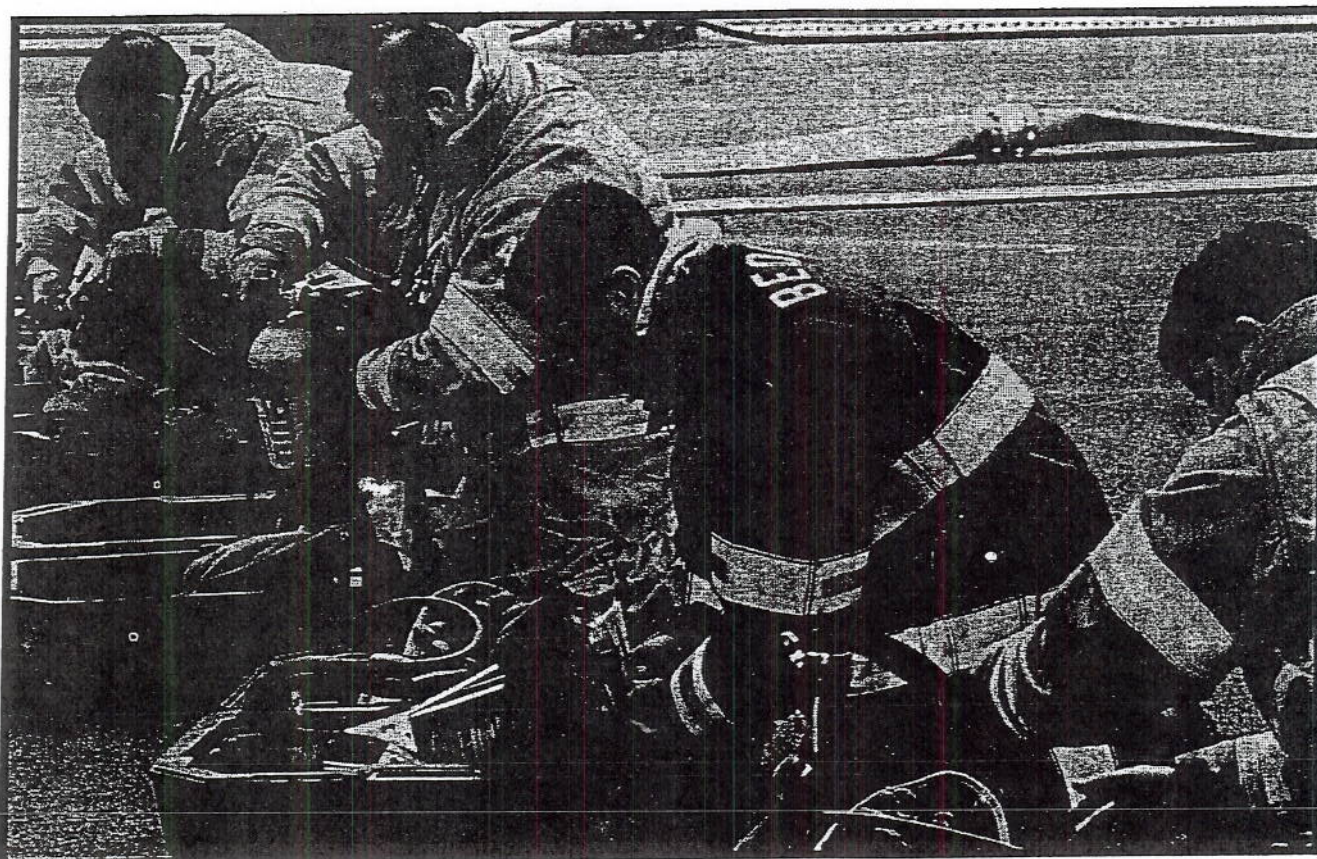


Protective Breathing: Search and Rescue



Student Handbook

Department of Fire Services / Massachusetts Firefighting Academy
PO Box 1025 – State Road
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978.567.3200
www.mass.gov/dfs



Department of Fire Services
Massachusetts Firefighting Academy

Protective Breathing



Segment I

Personal Protective Equipment

2

Concepts and limitations of a protective envelope:

- Hazards at the Fire Scene
- General Approaches to Protection
- Concept of Protective Envelope
- General Limitations

3

Describe the purpose, functional features, limitations, and care of protective equipment for the following:

- Head
- Eyes and Face
- Body
- Hands
- Feet
- Ears

4

Safety Features of Helmets



- Impact Cap
- Suspension Harness and Liner
- Brim
- Chin Strap
- Face Shield or Goggles
- Reflective Trim
- Ear Flaps



5

Limitation of Helmets

- Exposure to extreme temperatures
- Weight
- Hearing impairment
- Age / Condition

6

Care of Helmets

- Check impact cap for damage
- Clean shell regularly
- Repair fittings
- Adjust suspension harness
- Do not paint without manufacturer's OK
- Store leather helmets in cool dry space

7

Care of Protective Eyewear

- Clean regularly
- Inspect for cracks
- Mounting hardware secure
- Check rubber goggle straps for pliability

8

Layers of Turnout Gear

- Outer Shell
 - flame and water resistant
- Vapor Barrier
 - prevents vapor penetration
 - allows body heat to dissipate
- Inner lining
 - thermal protection

9

Other Features of Turnout Gear

- Collars
- Closures
- Fasteners
- Wristlets
- Length of pants and coat

10

Limitations of Turnout Gear

- Flame resistant not heat proof
- No protection from corrosive liquids
- Weight
- Bulkiness
- Holds in body heat

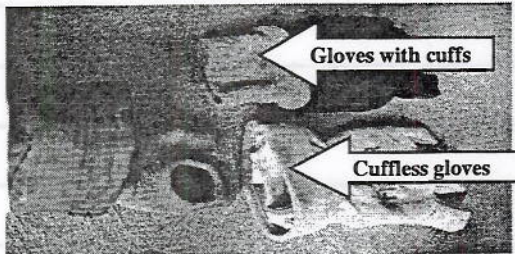
11

Care of Turnout Gear

- Inspect layers regularly
- Inspect closures and fasteners
- Clean as necessary
 - Wash every six months or after any major incident
 - Air dry

12

Types of Gloves



13

Gloves

- Protection from injury
- Not water resistant
- No chemical barrier
- Limited thermal protection
- Not puncture proof

14

Care of Gloves

- Inspect for wear and tear
- Replace if damaged
- Clean periodically
- Dry after use

15

Features of Protective Footwear

(Rubber or Leather)

- Protects against heat, impact and puncture
- Provides traction
- Electrical insulation only when new
- Safety toe
- Metal insole plate
- Waterproof

16

Limitations of Footwear

- Correct fit
- Weight contributes to fatigue
- Limited insulation from cold

17

Care of Turnout Boots

- Store in cool dark area
- Inspect regularly
- Clean regularly
- Do not share boots

18

Additional Types of Protective Equipment

- Safety Belts
- PASS Devices
- Hearing Protection
- Eye Protection

19

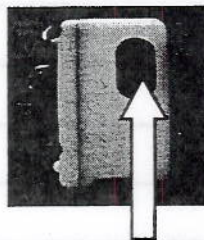
Safety Belts

- Seat Belts
- Ladder Belts
- Harnesses (OSHA approved)

20

PASS Device

- This is a manually activated pass device, it can be activated for normal operation by depressing both buttons, located on each side of the device, simultaneously. A chirp will sound and a LED light will flash assuring the operator that it is activated
- To deactivate use the same procedure



Depress on both sides

21

Firefighting is a strenuous, demanding activity.

Although protective gear is designed to protect firefighters, it can also work against them.

The SCBA alone can weigh from 25-35 lbs. and complete PPE can add 50-70 lbs to the firefighter.

22

Segment II



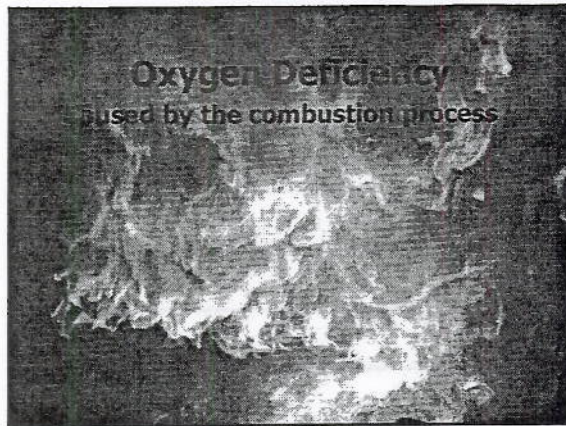
Respiratory Hazards

23

Types of Respiratory Hazards

- Oxygen Deficiency
- Elevated Temperatures
- Smoke
- Toxic Atmospheres

24



Reduced Oxygen

- 21% Normal conditions
- 17% Some muscle impairment, increased rate of breathing
- 12% Dizzy, headache, rapid fatigue
- 9% Unconsciousness
- 6% Death within a few minutes

26

Elevated Temperatures

- Air above 120°
- Effects of elevated temperatures
 - decrease in blood pressure
 - circulatory failure
 - fluid in lungs
 - tissue damage

27

Smoke

■ Components:

- Mostly dust, carbon, and tar particles
- Visible smoke is a suspension of small particles that are solid or liquid
- Toxic vapors may condense on airborne particles
- Vapors (liquid droplets)
- Fumes (solid particles formed by condensation of airborne vapors formed from solids)

28

Smoke

■ Particle size affects penetration:

- Mucous membranes and nasal hairs trap larger particles
- Smaller particles penetrate to alveoli

29

Smoke

■ Effects of Smoke:

- Irritation of lungs and respiratory tract
- Inflammation of lungs
- Pneumonia
- Suffocation
- Emphysema
- Nausea, vomiting, diarrhea
- Symptoms specific to the agent inhaled

30

Toxic Atmospheres

- May contain chemicals present as a result of the combustion process
- May contain chemicals present at the scene as a result of a spill or leak

31

Toxic Atmospheres

- Types of gases produced by fire and amounts produced depend on:
 - Type of fuel(s) burning
 - Rate of heating
 - Temperature at which gases form
 - Amount of oxygen

32

Toxic Atmospheres

- Effects of Toxic Atmospheres:
 - Depends on amount of mixtures inhaled
 - Immediate damage to respiratory system
 - Enter bloodstream and cause damage elsewhere in the body
 - Impair ability of red blood cells to transport oxygen
 - May cause chronic (long-term) damage

33

Identify physical characteristics, exposure sources, and symptoms for each of the following gasses:

- | | |
|---------------------|-------------------|
| ■ Carbon Monoxide | CO |
| ■ Carbon Dioxide | CO ₂ |
| ■ Hydrogen Cyanide | HCN |
| ■ Hydrogen Chloride | HCl |
| ■ Nitrogen Oxides | N ₂ O |
| ■ Phosgene | OCCL ₂ |

34

Carbon Monoxide (CO)

- Colorless, Odorless, Tasteless, Combustible
- Present in every fire
- Produced from incomplete combustion
- Considered a chemical asphyxiant
- Absorbed into system 200 times faster than oxygen

35

Effects of CO Exposure

- | | |
|------------|---------------------------|
| 100 PPM | - No symptoms |
| 200 PPM | - Mild headache |
| 400 PPM | - Headache after 1-2 hrs. |
| 800 PPM | - Collapse after 2 hours |
| 1000 PPM | - Collapse after 1 Hour |
| 1600 PPM | - Dizzy, nausea, 20 min |
| 3200 PPM | - Collapse after 30 min |
| 12,800 PPM | - Death in 1-3 minutes |

36

Carbon Dioxide (CO₂)

- Colorless, odorless and tasteless
- Produced in every fire
- Produced from complete combustion
- Stimulates respiratory system
- Higher levels paralyze the brain's respiratory center

37

Carbon Dioxide (CO₂)

5,000 ppm	0.5%	No symptoms
20,000 ppm	2.0%	Resp. rate increases by 50%
30,000 ppm	3.0%	Resp. rate doubles
50,000 ppm	5.0%	Vomiting, dizziness
80,000 ppm	8.0%	Difficulty breathing
100,000 ppm	10.0%	Death in minutes

38

Hydrogen Cyanide (HCN)

- Present at every fire
- Absorbed through skin
- Chemical asphyxiant
- Colorless
- Combustion of wool, nylon, polyurethane
- Used as a fumigant

39

Hydrogen Cyanide (HCN)

- IDLH 50 ppm
- .005 % in air
 - Plastics
 - Gas Chambers
 - Heart Failure
 - Bitter Almond Odor

40

Hydrogen Chloride (HCl)

- Lingers during overhaul
 - Do not remove your SCBA too soon
- Colorless
- Pungent, extremely irritating odor

41

Hydrogen Chloride (HCl)

- IDLH 50 ppm
- .005 % in air
 - Throat Swelling & Suffocation
 - PVC Plastics
 - Telephone & Electrical Cables

42

Nitrogen Oxides

- Two types
 - Nitrogen Dioxide (NO_2)
 - Nitric Oxide (NO)
- Nitrogen dioxide-reddish brown, irritating odor
- Death by suffocation
- Forms nitric acid when dissolved in water

43

Nitrogen Oxide (NO)

- Nitrogen Oxide- Sometimes called "laughing gas" may be found in medical facilities-produced by the burning of plastics, nitrous films and nitrous oxide fertilizer
- Colorless & odorless
- Heavier than air
- Small doses cause stupor, lightheadedness, loss of some sense of pain
- Large doses cause suffocation
- Converts to nitrogen dioxide in air

44

Phosgene (COCl_2)

- Colorless and tasteless
- Produced from fires involving refrigerants
- Combines with moisture in lungs to form hydrochloric acid
- Full effects may take hours to develop

45

Sulfur Dioxide (SO₂)

- Produced by burning rubber, gasoline, oil and sulfur products
- May be found in large quantity in old (pre-1950) refrigerators in railroad cars
- May be found in gaseous or candle form used as a fumigation gas
- Colorless with as suffocating odor that is extremely irritating
- Causes paralysis of the respiratory tract leading to suffocation by pulmonary edema

46

Ammonia (NH₃)

- IDLH 500 ppm
- .05 % in air
 - Refrigerant - Skating Rinks
 - Highly Pungent Suffocating Odor
 - Pulmonary Edema
 - Burning Eyes & Throat
 - Weeping Eyes

47

Chlorine (Cl₂)

- IDLH 30 ppm
- .003 % in air
 - Swimming Pools
 - Greenish Yellow Gas
 - Heated Plastics
 - Foam Rubber
 - Burning Eyes, Nose, Mouth

48

Section III

Types of Breathing Apparatus

49

Operation and Safety

- Two categories of breathing apparatus
 - Open Circuit
 - Closed Circuit (Re-breather)
- Types of open circuit breathing apparatus
 - Demand Type (Older no longer used)
 - Positive Pressure Type

50

Demand Type SCBA

- OSHA and NFPA standards do not allow demand type apparatus to be used during firefighting
- This type of SCBA only releases air to the user when a breath is taken. This may allow contaminants to enter the facepiece

51

**Open and Type
Breathing Apparatus
does not meet
the NFPA 1981 Standard**

52

Open Circuit Positive Pressure

Breathing apparatus must be **OPEN
CIRCUIT-POSITIVE PRESSURE** for
today's firefighting operations and to
meet the NFPA standard

53

Closed-Circuit

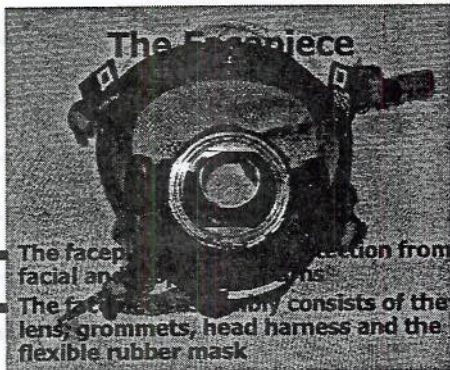
- Closed circuit SCBA compressed or liquid oxygen (not air)
- Closed circuit SCBA is known as rebreather apparatus because the user's exhaled air stays within the system
- Closed circuit SCBA is not used for firefighting but for hazardous materials incidents
- Available from 30 minutes to 4 hour durations

54

Facepiece

- Facepiece Lens
- Exhalation Valve
- Webbing or Straps
- Different Sizes

55

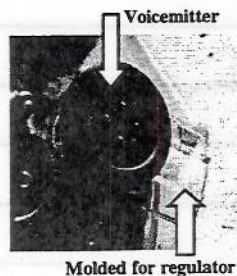


- The facepiece provides protection from facial and eye injuries
- The facepiece assembly consists of the lens, grommets, head harness and the flexible rubber mask

56

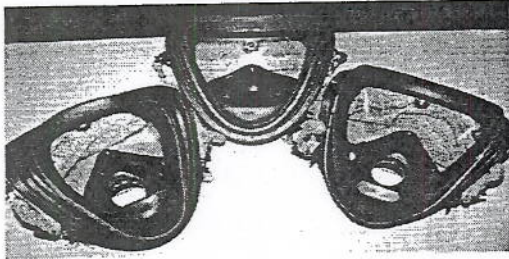
The Facepiece

- The facepiece has a speech diaphragm, (voicemitter), this allows communication to be clearer. The user must talk slowly and loud when communicating
- The lens is molded to lock in the regulator



57

Properly Fitted



58

Facial Hair

- In order to fit properly, the facepiece must fit against bare skin
- Firefighters should wear short hair and be clean shaven according to:
 - OSHA
 - NIOSH
 - NFPA
 - ANSI

59

The Facepiece

- The facepiece's nose cup will deflect exhalations away from the lens
- Internal fogging is the result of a cool lens causing the highly humid exhaled breath to condense



Nose Cup

60

Backpack Assembly

- Holds air cylinder in place
- Straps hold apparatus on back
- This backpack assembly is made of an aircraft aluminum alloy to reduce weight



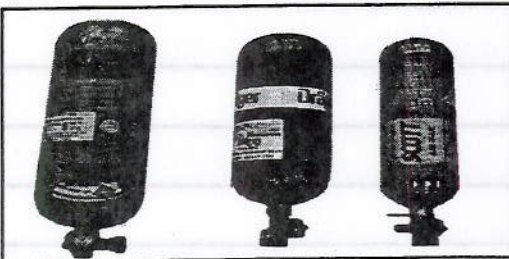
61

Air Cylinder

- Construction
 - steel, aluminum, fiberglass, carbon
 - different ratings
 - 30 – 45 – 60 minutes
 - discoloration indicates exposure to heat

62

Cylinder Brands



63

Additional Components

- Remote Pressure Gauge
- First Stage Pressure Reducer
- Second Stage Pressure Reducer
- Audible Alarm(s)

64

The Line Gauge

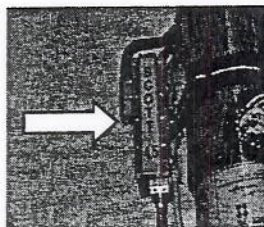
- The line gauge should read within 100 psi of the cylinder gauge



65

High Pressure Regulator (Reducer)

- Reduces the pressure from 4500 psi or the pressure contained in the cylinder to 100 psi
- Non-serviceable internal mechanism



66

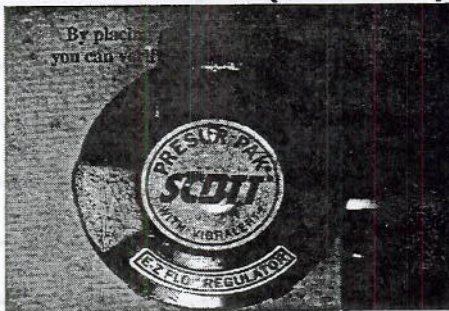
Low Pressure Regulator

- Reduces pressure from 100 psi to approximately 20 psi. This is to create a positive pressure environment within the facepiece



67

Low Air Alarm (Vibra-Alert)



25% = 1125 psi of 4500 psi

68

The Low Air Alarm

Do not be misguided by the rule of thumb that says that you have 5 minutes left when the low air alarm activates!

When the low air alarm sounds, you have approximately $\frac{1}{4}$ of the tank volume left.

69

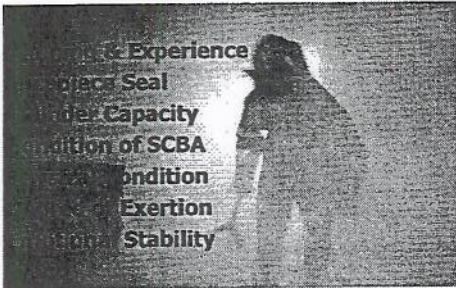
Segment IV

Limitations of Breathing Apparatus

70

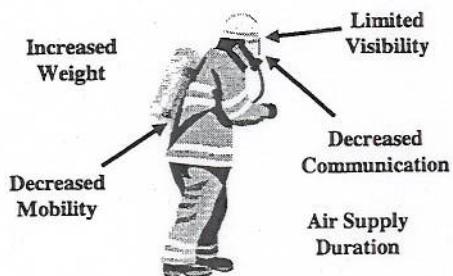
Air Supply Limitations

- Skill & Experience
- Face Seal
- Lung Capacity
- Condition of SCBA
- Physical Condition
- Exertion
- Posture Stability



71

Limitations of Equipment



72

Individual Factors

- Physical Condition of Wearer
- Level of Exertion
- Response to Mental Stress
- Training and Experience

73

Segment V



Donning Breathing Apparatus

74

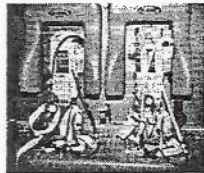
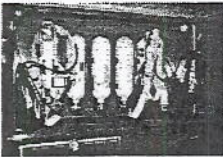
Donning Breathing Apparatus

- Store Apparatus Ready to Don
- Prepare to Don Apparatus
- Over the Head Method
- Coat Donning Method

75

Stored Apparatus

- Backpack harness straps clear
- Seat mounted
- Compartment mounted
- Stored in cases



76



Prepare to Don
Apparatus



Over the Shoulder Method

78



Coat Method of Donning

- Grasp left shoulder strap with left hand
- Reach behind with right arm, insert
- Tighten shoulder straps
- Fasten and tighten waist straps
- Don facepiece

79



Seat Method of Donning

The unit must be checked and the cylinder charged before being placed in the mounting bracket

- Insert arms through shoulder straps
- Fasten and tighten straps
- Dismount vehicle
- Don facepiece, hood, helmet, gloves

80



Compartment Method of Donning

Basically the same technique as overhead donning from the case

- Prepare SCBA for donning
- Release SCBA from bracket
- Back up, slide arms through straps
- Tighten straps
- Don facepiece, hood, helmet, gloves

81

Donning Facepiece

- Hood before coat
- Spread harness
- Position chin in chin cup
- Slide harness up and over
- Pull bottom straps back to tighten: not out
- Tighten temple straps
- Check seal for leaks
- Pull hood into place

82

Connect Regulator

- Don helmet, fasten and tighten chin strap
- Connect regulator to facepiece
- Inhale
- If no air, check that cylinder valve is open

83

Removing Facepiece

- Depress don/doff switch if so equipped
- Remove regulator
- Remove helmet
- Slide hood back
- Loosen straps
- Remove chin first. Pull up and back
- Reattach facepiece to regulator
- Store facepiece out of way

84

Emergency Procedures

In the event that the breathing apparatus fails to supply air, the following emergency procedure should be followed

- Notify CO that you have a problem
- Check that cylinder valve is open fully
- Activate bypass valve (purge)
- Notify crew that you are exiting area
- Report to IC or Safety
- Tag and remove SCBA from service
- Activate PASS if needed

85

Segment VI

Inspection and Maintenance

86

Daily Checks

- Check Cylinder Pressure
- Check Hoses
- Check Exhalation Valve
- Check Alarms
- Check Valve Positions
- Check Harness and Straps

87

Check Cylinder Pressure

- Cylinder must be at least 90% full
- Cylinder and remote gauges within 100 psi
- Hydrostatic test date

88

Hydrostatic Test Date

The DOT number will indicate the proper time frame for the hydrostatic test date.

After certain dates the cylinder may not have to be tested any further.

Newer composite cylinders will have a 5 year test date.

89

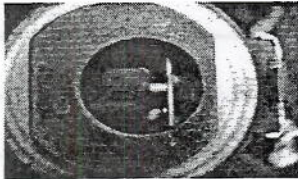
Check Hoses

- Worn or Broken
- Cracks
- Tight Connections
- "O" Ring

90

Exhalation Valve

- Worn, damaged
- Free of foreign matter



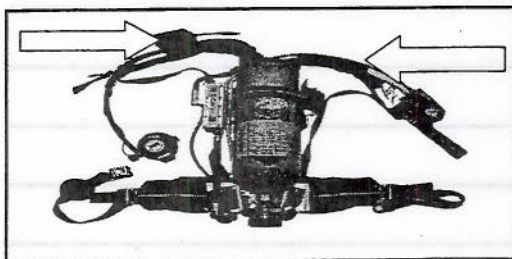
91

Additional Checks

- Alarms
- Valve Positions
- Harness Integrity
- Backplate

92

The Shoulder Straps



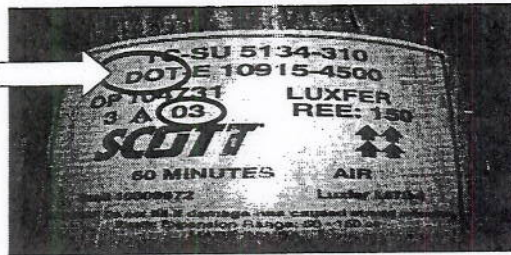
93

Maintenance of SCBA

- Recharge or replace cylinder
- Inspect high pressure connections
- Inspect low pressure connections
- Inspect facepiece and hoses
- Clean facepiece
- Clean harness
- Remount apparatus

94

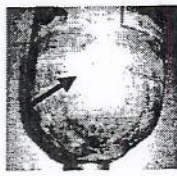
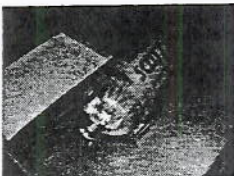
DOT Marking



95

Cylinder Damage

- Heat
- Wear



96

The "O" Ring

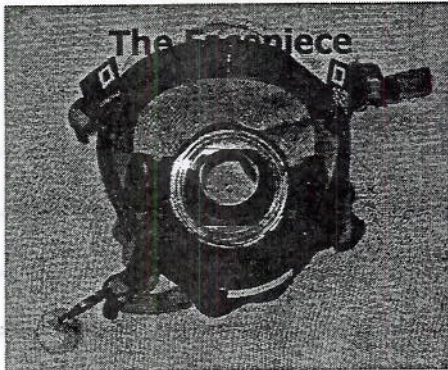
(Made of Neoprene rubber)

Always check to see if the "O" ring (gasket) is in place and properly secured by the allen screw



"O" Ring

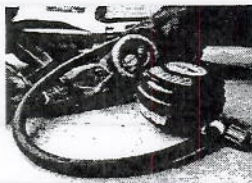
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98

Low Pressure Hose

- The low pressure line is flexible to allow for the movement of the user. Due to the line's flexibility the hose is susceptible to cuts, slices and abrasions
- The hose must be checked at least weekly

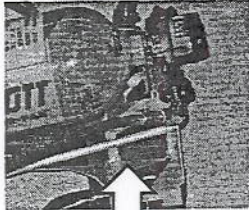


Must feed off the left shoulder

99

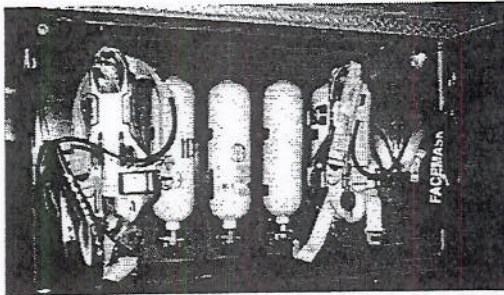
High Pressure Hose

- Always check the high pressure hose for any fraying, rips or tears. Check for leaks once the SCBA is activated.



100

Remount SCBA

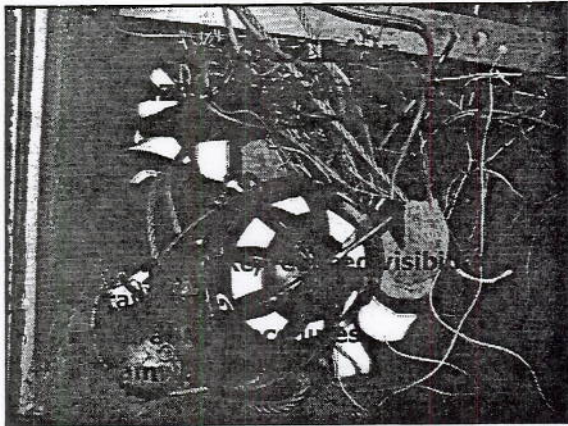


101

Segment VII

Safety and Special Techniques

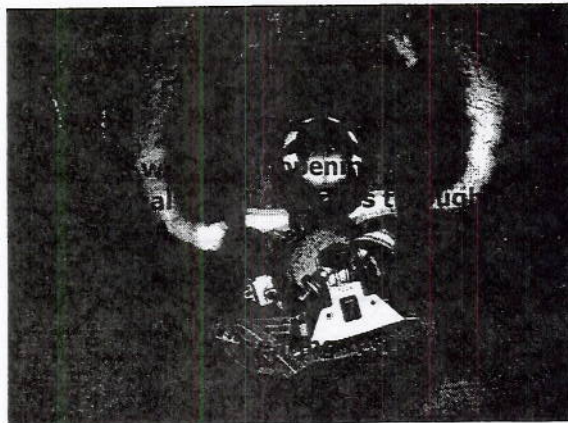
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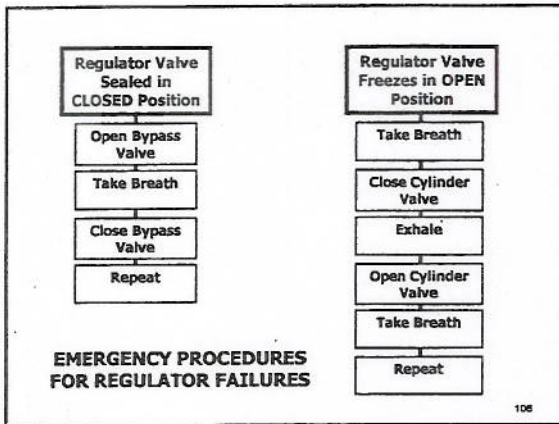


Procedures

- Operate in pairs
- Use rope as lifeline
- Use hose as lifeline
- Follow wall

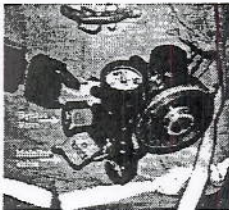
104





Bypass/Purge Breathing

- Open bypass valve slowly (Purge Valve)
- Deep breath and hold
- Close valve
- Exhale
- Repeat



107

Regulator Breathing

1. Remove regulator from facepiece
2. Remove facepiece
3. Place regulator at mouth
4. Form seal around regulator and mouth
5. Inhale
6. Close donning switch
7. Exhale
8. Repeat Steps 3 - 7

108

The Massachusetts Firefighting Academy does not support present methods of Buddy Breathing for the following reasons:

109

- All known methods of buddy breathing will compromise the integrity of the rescuer's SCBA
- The rescuer will possibly run out of air due to the increased usage
- A panic stricken victim may not share use of the air supply

110

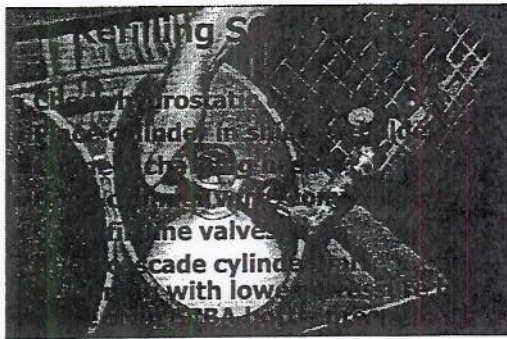
- Call for Rapid Intervention Team
- Usually it's faster to just go out the nearest exit with your partner following to make sure you make it
- If the victim is still breathing, bring an air supply from the outside, or drag him/her out as quickly as possible

111

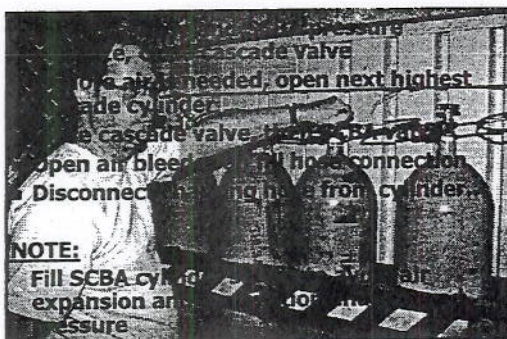
Replacing Air Cylinder

- Doff SCBA apparatus
- Close cylinder valve, purge system
- Disconnect high pressure hose
- Release cylinder clamp, remove bottle
- Place new cylinder in apparatus, lock
- Connect high pressure hose
- Open cylinder valve fully, listen for alarm

112



113



114

Cylinder Refill

- Cylinders can be filled at a rate of 300 to 600 psi in order to reduce the amount of cylinder heating that occurs during the compression of air
- By filling at a lower rate, the amount of heating is reduced
- Once the cylinder has cooled, the pressure gauge will have a lower pressure reading than when it was initially filled

115

CONTROLLED BREATHING	SKIP BREATHING
1. Inhale through the mask	1. Inhale
2. Hold the breath for 10 seconds	2. Exhale
3. Exhale through the mask	3. Inhale
4. Repeat the cycle	4. Exhale
5. Monitor the pressure gauge	5. Monitor the pressure gauge
6. Repeat the cycle as needed	6. Repeat the cycle as needed

Techniques for Maximizing Air

- 'Skip Breathing'
- Controlled Breathing
- Air Supply Duration

116

Controlled Breathing
1. Inhale through the mask
2. Hold the breath for 10 seconds
3. Exhale through the mask
4. Repeat the cycle
5. Monitor the pressure gauge
6. Repeat the cycle as needed

'Skip Breathing'

- Involves taking a regular breath, holding it, then taking another breath before exhaling
- Use normal breaths and exhale slowly

117

'Skip Breathing'
1. Inhale through the mask
2. Hold the breath for 10 seconds
3. Exhale through the mask
4. Repeat the cycle
5. Monitor the pressure gauge
6. Repeat the cycle as needed

BREATHING TECHNIQUES

SKIP
Inhale
Exhale
Inhale
Inhale
Exhale
+
Normal breaths used to extend the use of remaining Air while keeping the CO ₂ in lungs in proper balance

CONTROLLED
Normal inhalation through the nose
Exhaled through the mouth
+
Decreases the amount of air consumed

Controlled Breathing

- This method is most efficient
- Inhale through nose, exhale through mouth

119

Air supply duration varies with the following:

- Firefighter conditioning
- Task performed
- Level of training
- Operational environment
- Degree of excitement
- Other variables

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General Safety Precautions

- Be in good health and condition
- Use only certified equipment
- Know protective limits
- Monitor air supply
- Be prepared for problems

121

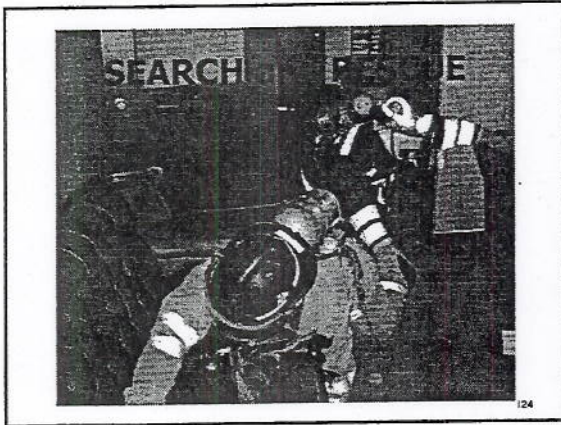
General Safety Procedures

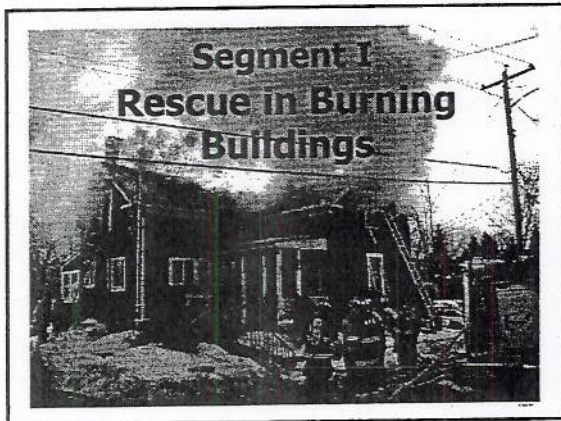
- Work in pairs
- Do not wear hard contact lenses
- Do not use with respiratory illness
- Check facepiece seal
- Close bypass/purge valves
- Keep harness straps connected and snug

122

- Stay in contact with wall, hose, rope
- Do not remove SCBA until out of area
- Do not remove SCBA until atmosphere has been checked for safe O₂ levels

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Search Procedures

- One of most dangerous operations
- Work in pairs
- Wear full PPE
- Have plan before beginning
- Remain oriented to building
- Use walls, hose or ropes

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Search Procedures

- Maintain dialogue
- Carry necessary tools and equipment
- Check air supply (gauge)
- Note location of doors and windows

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Search Strategies

Primary Search:

the first search of an area in a quick, systematic fashion

Secondary Search:

a more thorough systematic search conducted after fire has been controlled

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Primary Search

- Time is critical
- Use thermal imager if available
- Use hand tools to extend your reach
- Check all areas where victims might be
- Rely on sight, sound, and touch
- Follow walls and note turns

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Secondary Search

- Use thermal imager if available
- Locates victims missed in primary search
- Completed when conditions improve but may still present hazards
- Slow and methodical
- Use different firefighters
- Include all areas of the building

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Search Procedures

- Wear full PPE and SCBA
- Work in pairs
- Identify secondary means of egress
- Search on hands and knees
- Search room completely before moving on
- Enter and exit through same door
- Follow wall

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- Search all furniture
- Search all closets
- Pause and listen occasionally
- Move up and down stairs staying low
- Identify room has been searched
- Report unusual conditions to the IC
ie. fire extension, signs of collapse
- Use tool as extension of reach

133



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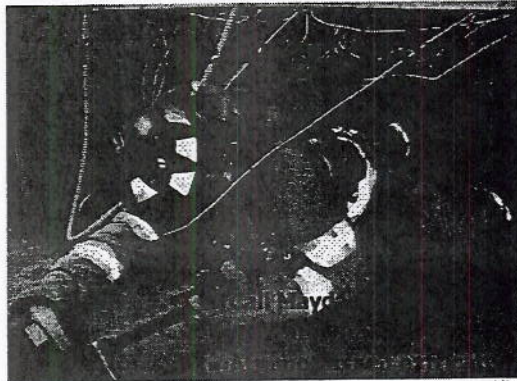


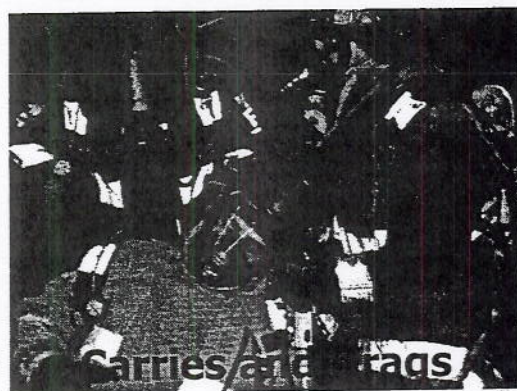
135

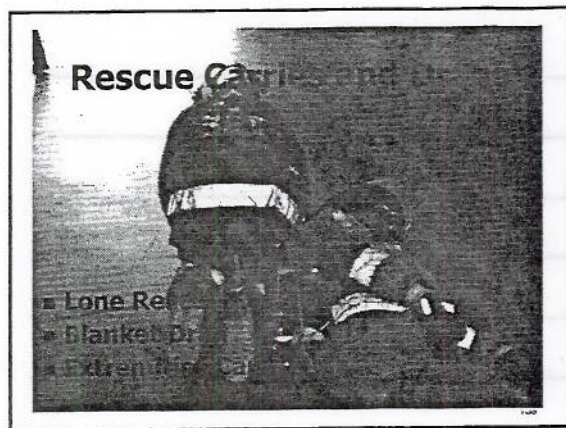
If You Become Lost

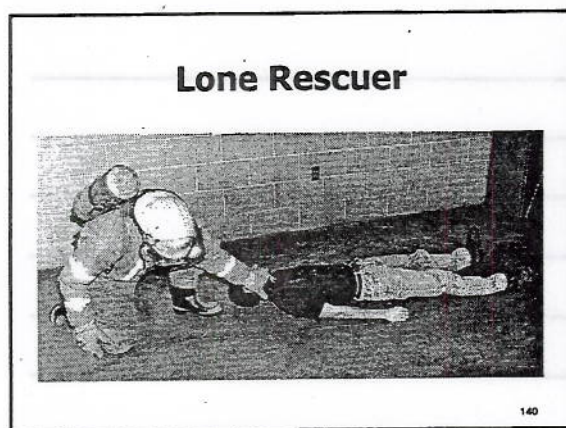
- Call "Mayday" on the radio
 - Give location if possible
- Activate PASS device
- Retreat down and out
- If not possible, go to room off hallway
 - Close door
 - Open window
 - Do not throw tools or PPE out window

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Extremities Carry



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Using Stretcher or Board



143

Stretchers

- 2 coats and 2 pike poles
- Blanket or salvage cover and 2 poles

Drags

- Rugs
- Curtains
- Coats
- Sheets
- Ropes
- Towels

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