Presentation 7 – Barbara LaClair

Fuel Exposures of U.S. Military During the Persian Gulf War

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Fuel Exposures in the Gulf War:

- Variety of fuels used in Gulf War – mostly jet fuel
- Jet fuel used in most military vehicles, including tanks and trucks
- One of the most widespread exposures during the War
- Jet fuel exposure associated with variety of toxic effects

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Fuel is vital to military operations

- 1.88 *billion* gallons of fuel used by U.S. military operations in ODS/S between August 10, 1990 and May 31, 1991
- Fuel Uses:
  - Vehicles, aircraft, equipment
  - Tent heaters, cooking stoves, portable generators
  - Dust & sand suppression
  - Fuels as solvents
  - Burning trash and wastes

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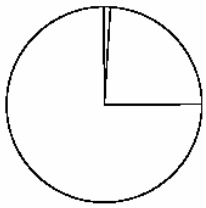
Types of Fuels Used During the Gulf War



☐Gasoline ☐Diesel ☐Jet Fuel

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Types of Fuels Used During the Gulf War

- Jet fuels, kerosene (Jet A-1, JP8, JP4, JP5) (75%)
  - Jet A-1 - Commercial fuel, primarily kerosene
  - JP-8 - Military version, Jet A-1 with additives
  - JP-4 – Kerosene/gasoline mix, being phased out in 1991
  - JP-5 - Primarily kerosene, Navy's primary jet fuel
- Diesel fuel (24%)
- Gasoline (leaded) (1%)

Fuels obtained from local sources - primarily from Saudi Arabia

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DoD Single Fuel Policy

- Adopted March 1988, in scheduled phase-in at start of ODS
- Goal - Reduce support requirements and maximize efficiency, by:
  - Minimizing number of different fuels required
  - Taking maximum advantage of locally available fuel
- **JP-8 designated as primary fuel for air and ground forces**

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JP-8 was used in….

- Aircraft (land-based)
- Helicopters
- Abrams Tanks
- Bradley Fighting Vehicles
- HumVees
- Heavy trucks

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Fuel handling personnel moving fuel lines, 101st Airborne Division Rapid Refuel Point

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JP-8 as the Fuel of Choice

- Replaced JP-4
- Similar to commercial Jet A-1, with additives
  - Static dissipator
  - Corrosion inhibitor
  - Icing inhibitor
- Contains less benzene (carcinogen)
- Contains less n-hexane (neurotoxicant)
- Thicker, less volatile
  - Reduced risk of fires, explosions

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Fuel handling personnel and M-978 tanker, 18th Aviation Brigade

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Incineration of human wastes

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Dust and Sand Suppression during the Gulf War

- "He described one brigade dumping 30,000 gallons of diesel fuel on the roads daily, and said U.S. service members living in tents near the roads and particularly truck drivers carrying out the spraying- complained of nausea from breathing the resulting fumes. As a result, the preventive medicine person to whom they reported obtained respirators for the drivers' use."

-- testimony of D. Johnson, U.S. Army Sanitary Engineer, to the NIH Technology Assessment Panel in 1994, as summarized in the Presidential Advisory Committee on Gulf War Veterans' Illnesses, Final Report, December 1996.

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Dust and Sand Suppression during the Gulf War

- "During the Persian Gulf War, JP-8 was routinely used to control and suppress desert sand, and combusted JP-8 was used to obscure troops and equipment. With desert surface temperatures commonly exceeding 120°F, substantial exposure may have occurred as a result of vaporization of JP-8. When vaporized jet fuel mixes with wind-blown ultrafine desert sand particles, pulmonary exposure is highly possible"

– *Toxicologic Assessment of Jet-Propulsion Fuel 8*, National Research Council, Subcommittee on Jet-Propulsion Fuel 8, Committee on Toxicology, National Academies Press, 2003

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Fuels used for dust suppression

"Because there is the potential for substantial exposure of troops to JP-8 when it is used to suppress desert sand and as a method of obscuring troops and equipment, the subcommittee recommends that the DOD no longer use JP-8 for those purposes"

- Toxicologic Assessment of Jet-Propulsion Fuel 8, National Research Council, Subcommittee on Jet-Propulsion Fuel 8, Committee on Toxicology, National Academies Press, 2003

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Types of fuels used varied…

- By branch of service,
- By unit,
- Over time

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DoD Single Fuel Policy - Implementation Issues

- Some Air Force units located on bases where only JP-4 available
- Army requested permission to use diesel fuel in ground equipment, to support generating smoke for tactical operations in M-1 tank, Abrams and Bradley vehicles
- Some Army & Marine units experienced power-related problems with ground vehicles, and attributed them to use of jet fuel
- Problems with fuel filters and injectors becoming clogged

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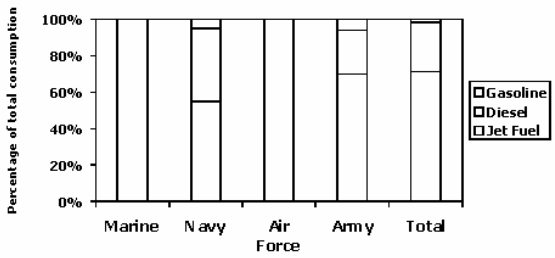
Fuel Consumption During ODS/S, by Branch of Service



Source: RAND, Assessment of DoD Fuel Standardization Policies, 1994

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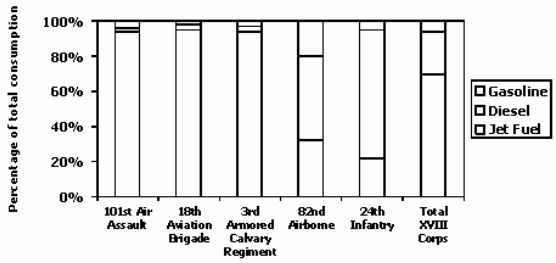
ODS/S Fuel Consumption, XVIII Corps, by Division



Source: RAND, Assessment of DoD Fuel Standardization Policies, 1994

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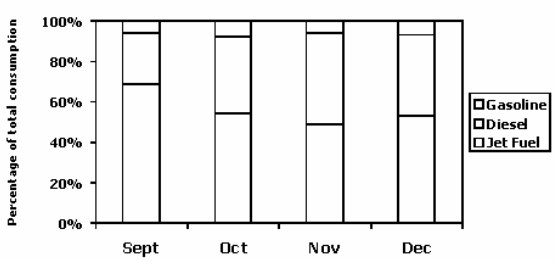
ODS/S Fuel Consumption, XVIII Corps, Late 1990



Source: RAND, Assessment of DoD Fuel Standardization Policies, 1994

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Health Effects of Fuel Exposures

Routes of exposure to fuels

- Inhalation
  - Vapors
  - Aerosols
  - Combustion products
- Dermal absorption
- Ingestion

JP-8 : Health symptoms reported

- Nausea
- Headaches
- Dizziness, lightheadedness
- Fatigue
- Blocked nasal passages
- Respiratory distress
- Skin irritation
- Smelling/ tasting JP-8 hours after exposure

Health Effects – JP-8 exposures

- Dermal effects
  - Irritation, rashes
  - Altered permeability to other substances
- Pulmonary effects
- Neurobehavioral changes
- Immune effects

JP-8 – Health effects of combined exposures

- Combined exposure to DEET, PB and JP-8 (in mice)
  - Fuel does not profoundly alter many immunological endpoints, but does selectively target functional endpoints
  - Suppression of antibody-specific IgM immune response (plaque-forming cell)
  - Decrease in delayed type hypersensitivity following high-dose exposure
- Peden-Adams M, Eudaly J, Eudaly E, *et al.*, Toxicology and Industrial Health 17:192-209 (2001)

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IOM Review - Health effects of exposures to fuels

- Review of over 800 peer-reviewed epidemiologic studies of human health effects of exposures to fuels, combustion products, and propellants
- Conclusion: Insufficient evidence of association between exposures to uncombusted fuels and any health outcomes evaluated

- Gulf War & Health, Volume 3: Fuels, Combustion Products and Propellants, Institute of Medicine, 2006

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Epidemiologic Studies of Fuel Exposures in Gulf War Veterans

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Fuel and petrochemicals – fumes, odors: How many were exposed?

Study	Population	Exposure	
Kang, 2000	11,441 Gulf War vets	Diesel, kerosene or other petrol fumes, incl. tent heaters, vehicle exhaust	80.4%
Unwin, 1999	3,284 U.K. Gulf War vets	Diesel or petrochemical fumes	84.0%
Wolfe, 2002	945 GW vets, Ft. Devens cohort	Diesel fuel odor	64.5%

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Fuel and petrochemicals – Skin/ dermal exposures: How Many Were Exposed?

Study	Population	Exposure	
Kang, 2000	11,441 Gulf War vets	Skin exposure to diesel or other petrochemical fuel	56.6%
McCauley, 1999	305 Gulf War Vets from OR, WA	Skin contact with petrol fuel	51.0%
Unwin, 1999	3,284 U.K Gulf War vets	Diesel or petrochemical on skin	66.6%
Australian Study, 2003	1,456 Australian Gulf War Vets	Solvents, oils, diesel or other fuel on skin	78.9%

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Exposure to Fuels: Association with symptoms

Study	Outcome	Exposure	Findings
Suadicani, 1999 (667 Danish GW vets)	Neuropsych sympt: memory, headache, dizziness, fatigue, sleep	Diesel, kerosene, other fumes	bivariate association with # symptoms p <= 0.01
		Evap. diesel on ground for dust	p <= 0.01
		Dermal contact, diesel/ other	p <= 0.001
		Bathing, drinking contam water (fuel, oil, chem)	bivariate association p <= 0.001, OR = 2.9 (1.8-4.6) in multivariate model
		Ingest contam food, fumes, oil, chem)	p <= 0.001

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Exposure to Fuels: Association with symptom complexes

Study	Outcome	Exposure	Findings
Gray, 2002 (11,868 Seabees)	GWI	oil sprayed for dust control	OR = 2.20 (1.85-2.60) (unadj) OR = 1.16 (0.92-1.46) (saturated)
Spencer, 2001 (1,119 ORNVA vets)	CMI	contact with fuel	OR = 3.76 (1.99-7.12) (unadj)
Unwin, 1999 (3,284 UK vets)	CMI	diesel/ petro fumes	OR = 2.1 (1.7-2.5) (unadj)
		diesel/ petro on skin	OR = 1.8 (1.5-2.1) (unadj)
Reid, 2001 (3,531 U.K GW vets)	CFS MCS	diesel on skin	OR = 1.8 (1.0-3.5) OR = 1.7 (0.8-3.6)
Wolfe, 2002 (945 Army vets)	CMI	diesel fuel odor	OR = 2.7 (1.9-3.9) (unadj)

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Exposure to Fuels: Association with symptom complexes

Study	Outcome	Exposure	Findings
Haley, 1997 (249 GW vets)	3 syndromes derived by factor analysis:	worked on sand sprayed w/ petro.	Syndrome 1 RR = 1.8 (0.6-5.6) Syndrome 2 RR = 2.1 (0.9-4.9) Syndrome 3 RR = 0.9 (0.4 – 2.0)
	1- impaired cognition 2- confusion-ataxia 3 – arthro-myo-neuropathy	drinking water had petro. taste	Syndrome 1 RR = 2.6 (0.9-7.7) Syndrome 2 RR = 2.8 (1.3-6.3) Syndrome 3 RR = 2.6 (1.2-5.6)

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Summary of Fuel Exposures

- Fuel exposures during the Gulf War were common and widespread
- Jet fuels (A-1 and JP-8) were the most widely utilized fuel types; use included ground vehicles and tanks
- Little objective data on fuel exposures – self-report, questions non-specific or ask about multiple exposure types

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Summary of Fuel Exposure Information from Gulf War Studies

- ~ 65 – 80% of Gulf War vets report exposure to petrochemical fumes, odors, or exhausts
- ~ 50 – 60% report dermal exposure to fuels, petroleum products

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Summary of Health Outcome Findings from Gulf War Studies

- Fuel exposures associated with chronic multi-symptom illness (ORs 1.8-3.8)
- Jet fuel: limited information from Gulf veteran epidemiologic studies

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Speakers : Health Effects of Jet Fuel Exposure

Effects on the Immune System	Dr. Mark Whitten
Neurological and Behavioral Effects	Dr. Glenn Ritchie

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