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# Case Studies of Motor Vehicle Fires

## CONTRACTOR:

Washington State Transportation  
Center at University of Washington

## SUBCONTRACTORS:

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DEPT OF TRANSPORTATION

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# ▶ Case Studies of Motor Vehicle Collision-Fires

- **On-site inspections**
- **Incident reconstruction and determination of fire causation**
- **Medical analyses**
- **Database of results**



# Research Objectives

**To provide publicly available data for the automotive engineering community and regulators that can both enhance the understanding of collision-fire incidents and be used to develop improvements to automotive safety**



# Research Completed

- **Two papers published to date**
- **DRAFT Final report provided to GM, NHTSA**
- **367 incidents reviewed**
- **35 detailed investigations**
- **Database of observations, 469 photos**





# Van Front to Cube Van Side Crash Information

- **1997 Plymouth Voyager (subject)**
- **1995 GMC 3500 cube van**
- **Van underride of cube van left side**
- **Delta V 12-17 mph**
- **1 occupant, broken hand**



# Voyager: Investigator

## Assessments:

- **Fuel:**
  - **Gasoline most likely (fuel rail breached)**
  - **Power steering fluid, coolant**
- **Ignition:**
  - **Electrical, mechanical spark most likely**
  - **Hot surface possible**
- **Initiation: Immediate**
- **Propagation time: Exting. 4-6 min.  
w/o spread to interior**

Times estimated from imprecise witness information



# Car Front to Pickup Rear Crash Information

- **1995 Ford Escort (subject)**
- **1997 GMC Sierra crew cab pickup**
- **Car underrode pickup**
- **Delta V 6-10 mph**
- **Injuries: None**



# Escort: Investigator

## Assessments:

- **Broken valve cover above shielded exhaust manifold**
- **Fuel likely: Engine oil, coolant**
- **Ignition:**
  - Hot surface likely
  - Electrical spark possible
- **Initiation: <2 minutes**
- **Propagation time: Exting. w/in 5 min. w/o spread to interior**

Times estimated from imprecise witness information



# Car Override of Culvert, Rollover Crash Information

- **1991 Mitsubishi Eclipse**
- **70-75 mph off right shoulder to allow ambulance right of way**
- **Lost control, override of culvert, rolled on roof**
- **Undercarriage damage, minor Delta V**
- **One occupant, back injuries**



# 1991 Eclipse: Investigator Assessments

- **Fuel: Engine Oil**
- **Ignition: Hot surface likely, mechanical spark possible**
- **Initiation: Immediate**
- **Propagation time: Fire extinguished before propagation to passenger compartment**

Times estimated from imprecise witness information



# 1991 Eclipse: Investigator Assessments Fuel Source

- **Undercarriage damage breached oil pan and spilled onto ground and exhaust system**
- **Oil only source of fuel**





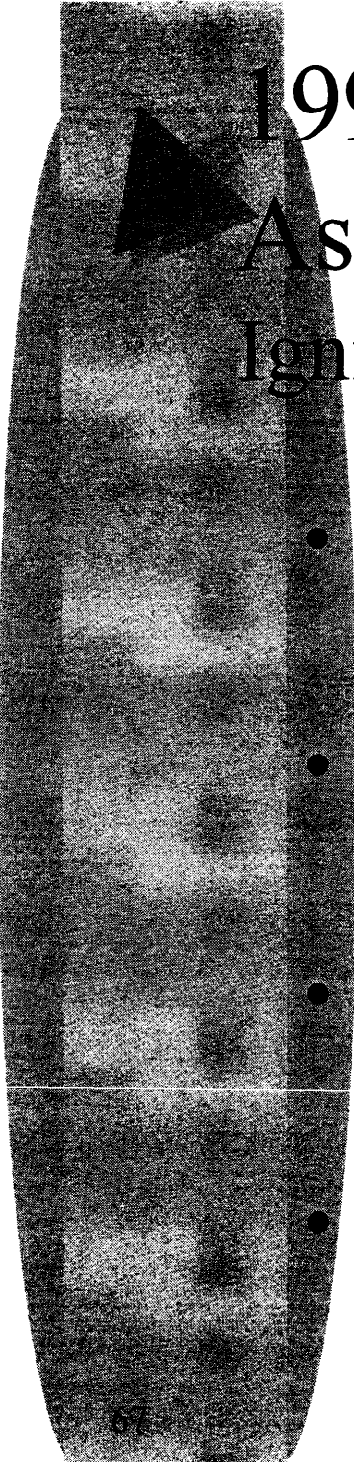
# 1991 Eclipse: Investigator Assessments

## Ignition and Propagation Time

- **Passing motorist informed driver of fire**
- **Fire witnessed center of vehicle toward front as driver exited vehicle**
- **Fire extinguished as driver walked 50 ft. from vehicle**
- **No consumables above exhaust system reduced propagation**

Times estimated from imprecise witness information





# 1991 Eclipse: Investigator

## Assessments

### Ignition Sources

- **Exhaust system shielded by a braided wire covering**
- **Fire sustained by oil vapor provided by the hot surface of exhaust pipes**
- **Entrapment of oil increases likelihood of ignition**
- **Fire damage confined to exhaust system**



# SUV Side by Car Front Crash Information

- **1992 Ford Explorer**
- **1991 Toyota Corolla**
- **Impact to right front wheel/fender**
- **Limited engine compartment intrusion**
- **Delta V 19-25 mph**
- **3 occupants: Driver ejected, broken vertebra**



# Explorer: Investigator Assessments

- **Fuel: Coolant most likely**
- **Ignition: Electrical spark, hot surface**
- **Initiation: Immediate**
- **Propagation time: 2-4 minutes**

Times estimated from imprecise witness information

## Explorer: Investigator Assessments Ignition and Propagation Time

- **When first observed by both drivers, flames 6-15 inches high**
- **Each described “pop” or “explosion” within 2-4 minutes**
- **Propagation to the interior immediately after sounds**
- **Described activities confirmed time estimates**



# Explorer: Investigator Assessments

## Fuel Source

- **Limited intrusion to engine compartment**
- **Heater hose likely breached at bulkhead**
- **Witnesses: Initial fire in rear and right rear of engine compartment**
- **No other liquid fuels in crush zone**

Times estimated from imprecise witness information

# Explorer: Investigator Assessments

## Ignition Sources

- **Power distribution box in crush zone**
- **Exhaust manifold shielded, possibly below autoignition temperature**
- **Mechanical sparks unlikely in area of initial fire**

**Electrical sparks are most likely ignition source**



# Non-Collision Car Fire

## Witness Reports

- **1999 Pontiac Grand Am**
- **5-10 mph on residential turning circle**
- **Power steering assist lost**
- **Smoke observed by 2 occupants**
- **Parked immediately**
- **Fire 1-3 minutes**

Times estimated from imprecise witness information

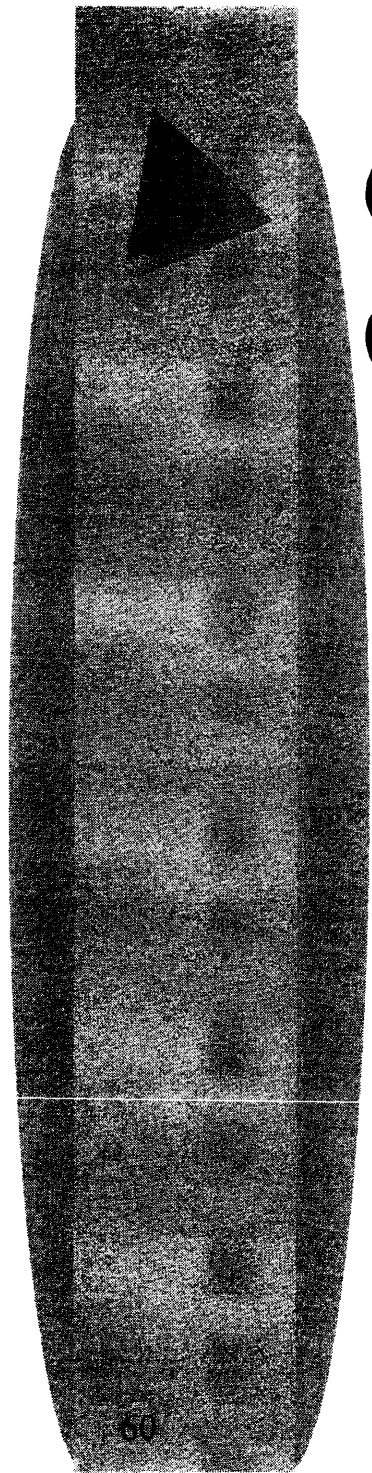


# Grand Am: Investigator Assessments

- **Fuel: Power steering fluid likely**
  - Gasoline, coolant, electrical possible
- **Ignition: Hot exhaust manifold likely**
- **Propagation time: Exting. w/in 9-12 min. w/o spread to interior**

Times estimated from imprecise witness information





# Car Front to Pickup Side Crash Information

- **1991 Plymouth Acclaim (subject)**
- **1993 Dodge Dakota pickup**
- **Car right front to pickup right rear**
- **Delta V 2-10 mph (subject)**
- **No injuries**



# Acclaim: Investigator Assessments

## Ignition and Propagation Time

- **Officer arrived: 2 minutes**
- **Fire began: 8-10 minutes**
- **Fire Extinguished: 9-11 minutes**
- **Officer turned ignition off**
- **Fire service arrived: 14 minutes**

Times estimated from imprecise witness information



# Acclaim: Investigator Assessments

## Ignition Sources

- **No impact damage to wiring**
- **Exhaust manifold not shielded, possibly below peak temperature**
- **No mechanical sparks (ignition long after impact)**

**Hypothesis: Spark ignition from electric cooling fan motor**



# Acclaim: Investigator Assessments

## Fuel Source(s)

- **Coolant system breached**
- **Extinguished immediately through grill**
- **Witness reports of whitish smoke, coolant odor**
- **No burn damaged wiring**
- **Fuses undamaged, battery 12.7 V**

Times estimated from imprecise witness information



# Acclaim: Investigator Assessments

- **Fuel: Coolant most likely**
- **Ignition:**
  - **Electrical spark most likely**
  - **Hot surface possible**
- **Initiation: 8-10 minutes**
- **Propagation:**
  - **Extinguished immediately**

Times estimated from imprecise witness information



# Acclaim: Investigator Assessments

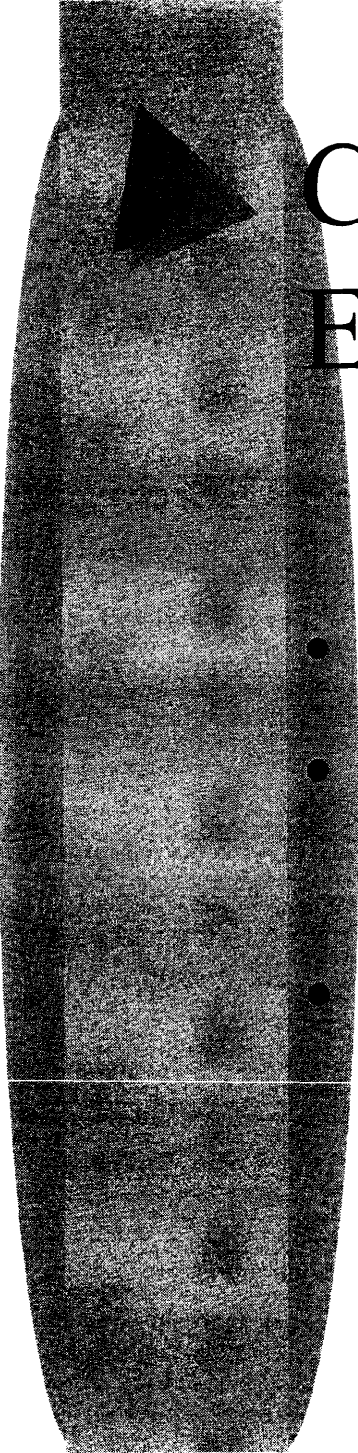
## Autoignition Potential

- **Pro**

- Engine operation, low coolant, not pressurized

- **Con**

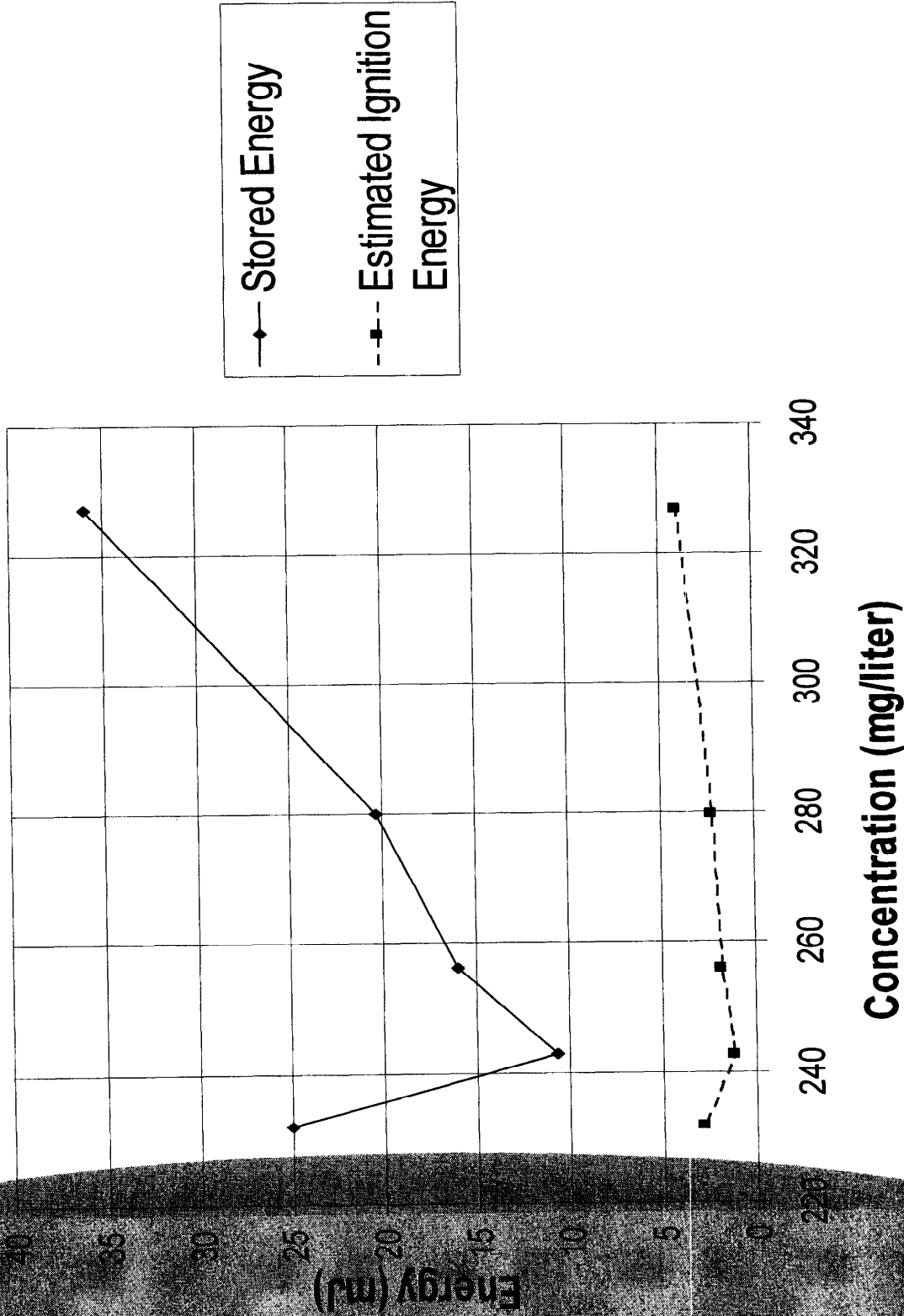
- Exhaust manifold cooler after long idle operation
- Not shielded
- High temperature required for coolant, without containment



# Coolant Minimum Ignition Energy

- **Procedure by ASTM 582**
- **50-50 mixture, Prestone Antifreeze/Coolant**
- **1.2 mJ minimum ignition energy**

# MIE Test Results





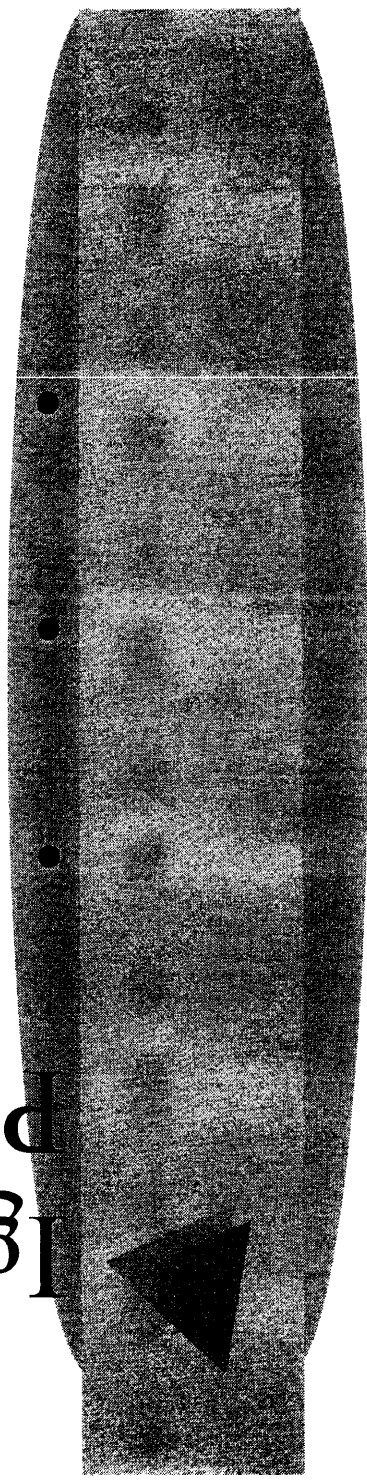


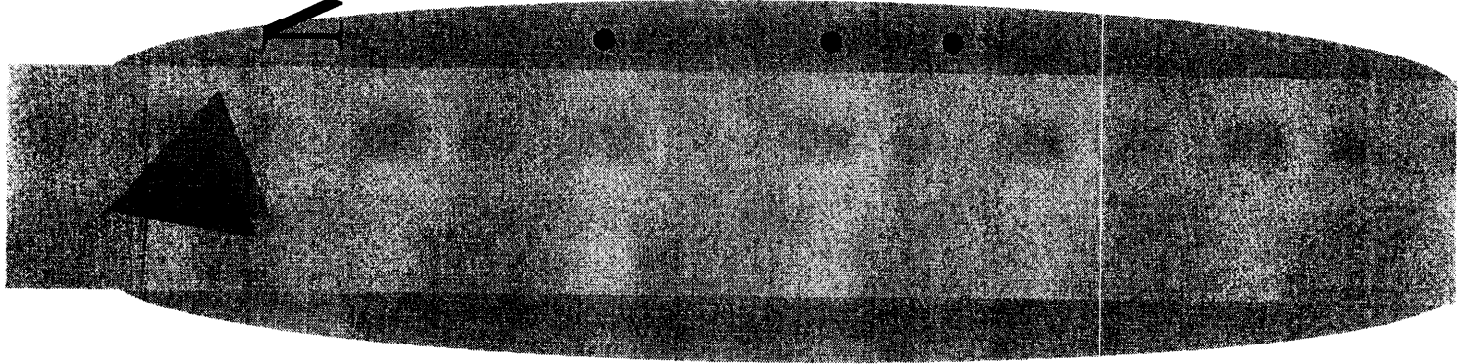
# Fan Motor Spark Energy

- **Exemplar Acclaim electric cooling fan motor tested**
- **Spark energy available from normal operation:**
  - **Startup: 280 mJ**
  - **Steady State: 25 mJ**

# Ignition by Motor Sparks Possible

- Spark energy well above MIE of coolant
- Other underhood fluids have lower MIE than coolant
- Questions remain for consideration



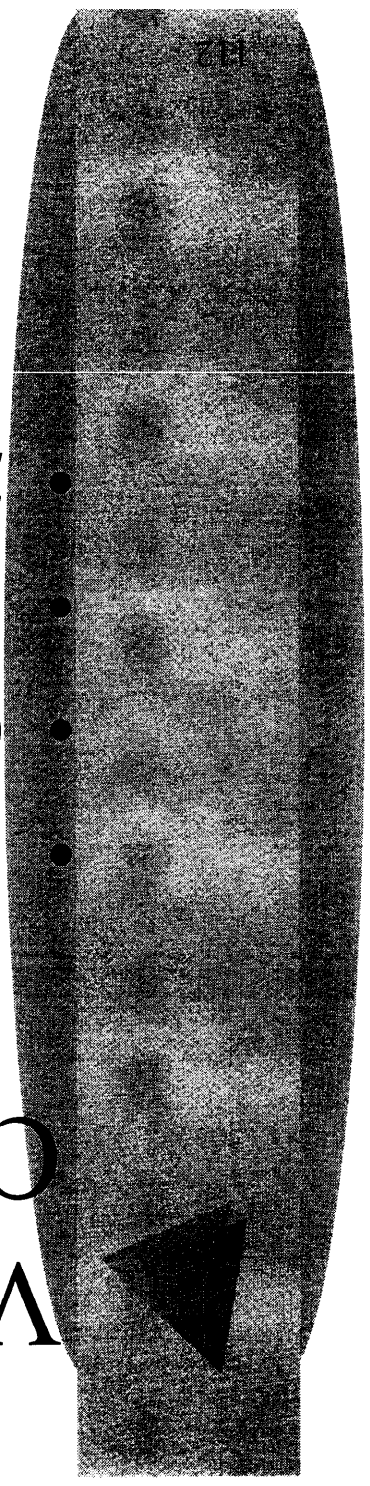


# Mechanical Spark Ignition

- **Collision (metal to metal or pavement)**
- **Dragging object**
- **Minimum ignition energy properties apply**

# Van Undercarriage Crash Information

- 1991 Toyota Previa
- Override of tow dolly
- Delta V minor
- 2 occupants, burn injuries



# Previa: Investigator Assessments Fire Investigation

- Tank breached by metal rod
- Fuel: Gasoline
- Ignition: Mechanical spark from tow dolly against pavement
- Initiation: Immediate
- Propagation time: Flames immediately in exit paths

Times estimated from imprecise witness information

