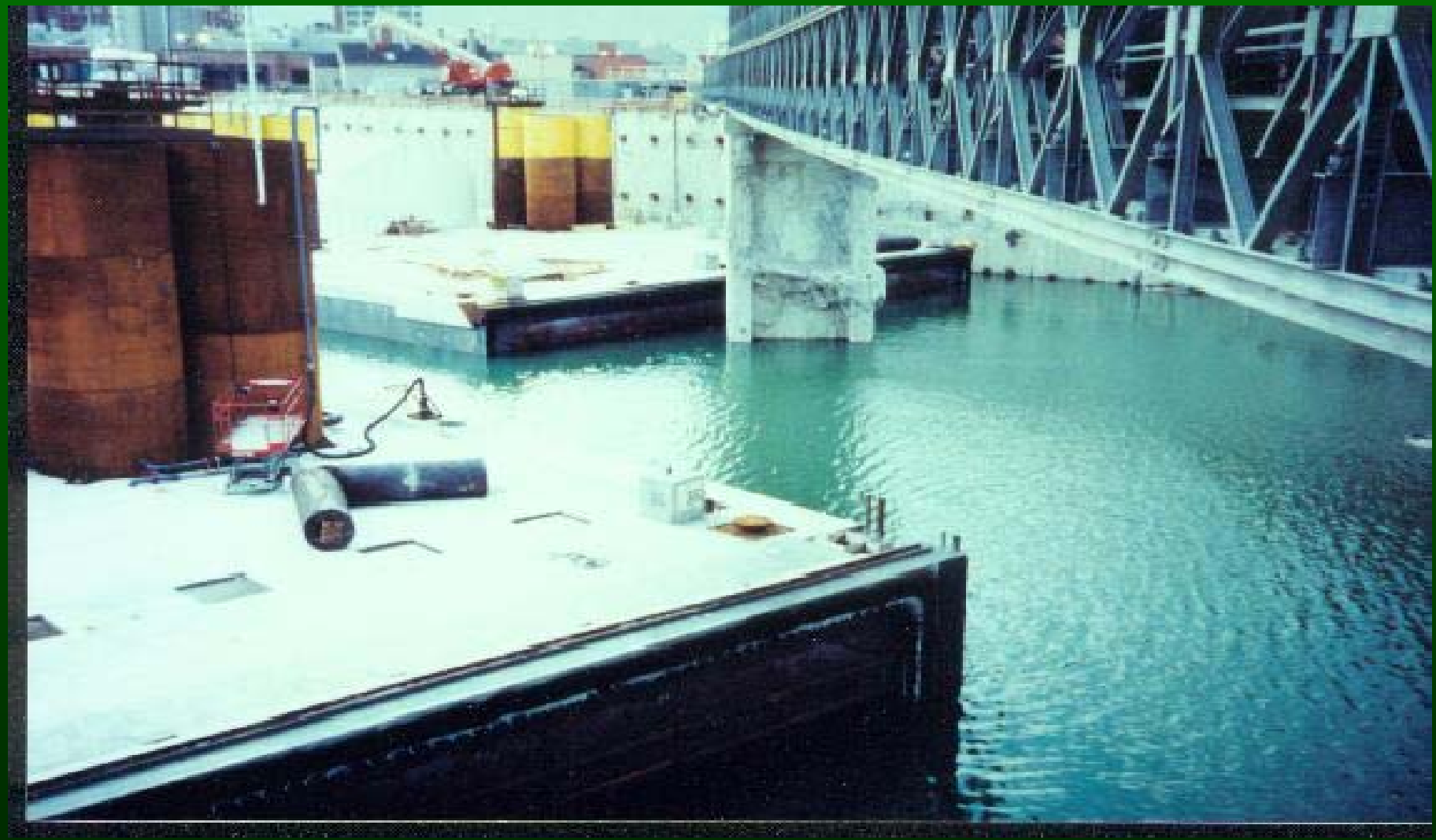
Evaluation of Airborne MDI Concentrations During Tunnel Wall Coating Application

- The **Big Dig** Project



Key Goals of Study were to be able to answer:

- What is the extent of release of diphenylmethane diisocyanate (MDI) during spray application of a polyurea waterproofing coating on to large surfaces outside, in the open or in enclosures?
- What steps should be taken to control exposures?
- What personal protective equipment is appropriate, based on the airborne data obtained?

Why Use a Polyurea Coating for this Project?

- Provided excellent waterproofing capability for structures to be placed underground and in and under water.

When Coatings/Sealers/Waterproofers Are Needed:

- Coatings
  - May contain hardener ingredients such as isocyanates which impart good performance properties
  - These ingredients can, however, cause health effects if worker exposure is not controlled
  - For example, isocyanates can cause:
    - eye, skin or respiratory irritation
    - allergic dermatitis or asthma

Big Dig Project: A Case Study

- Tunnel Sections to be Installed Below Ground and Water to Facilitate Traffic Flow in Boston, MA
- Sections were 100 Feet Long by 50 Feet Wide
- Multiple Year Project
- Reported Monitoring Study Done Outside in April

Four Application Areas

- Top of Tunnel Section, Covered by Tent (100 feet x 50 feet)
  - Spray application of polyurea coating (2-component, with MDI-based hardener) on to top surface
- Top of Tunnel Section, Covered by Tent (60 feet x 42 feet)
  - Spray application of polyurea coating, on to top surface
- Side of Tunnel Section, First Coat
  - Spray application of polyurea coating, sprayed from cherry picker against vertical surface
- Side of Tunnel Section, Second Coat
  - Spray application of polyurea coating, sprayed from cherry picker against vertical surface

Environmental Analytical Methods

- Diphenylmethane Diisocyanate (MDI)
  - 2,4' and 4,4' monomers were evaluated
  - Sampling
    - Nitroreagent Absorber Solution in Midget Glass Impingers backed by 13 mm Glass Fiber Filters coated with Pyridylpiperazine
    - A reagent in the collection liquid or coated on to the filter reacts with any MDI present in the sampled air stream to form a stable urea derivative which is subsequently analyzed
    - Sampling Done at Rate of 1.7 liters of air per minute

Environmental Analytical Methods

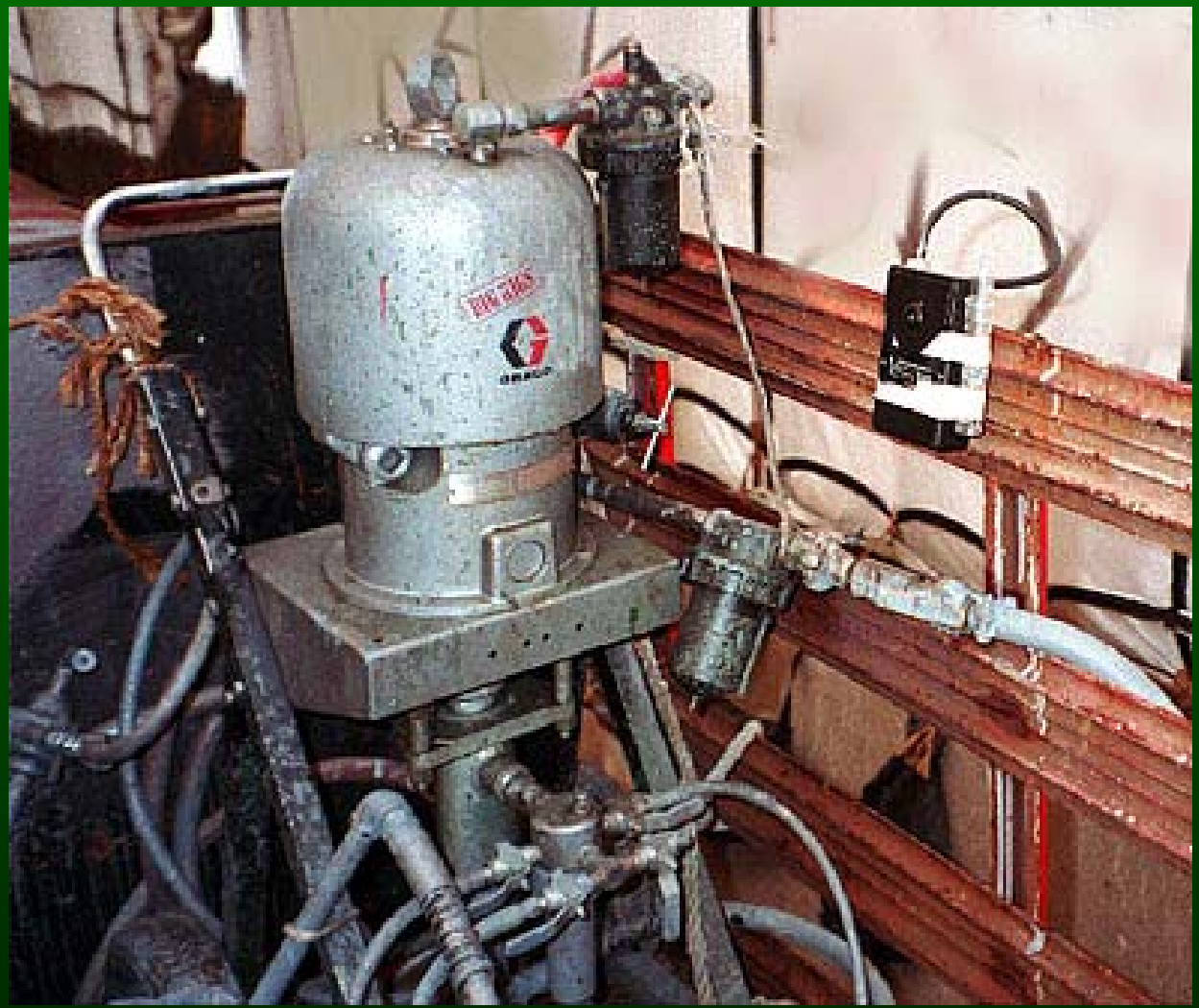
- Analysis
  - High Performance Liquid Chromatography
  - Bayer Corporate Industrial Hygiene Laboratory (accredited by American Industrial Hygiene Association – AIHA)

Sampling Procedures

- Personal or Breathing Zone samples attached to worker's lapel and reflect exposures if no respirator was worn
- Area samples are collected to determine the effectiveness of containment and/or the degree of dilution downwind of the spray operation
- Sampling pump airflow rates are calibrated prior to collection of each sample and actual flow rate at end of collection is measured. Average flow is calculated based on these numbers

Personal Protective Equipment Worn by Applicators

- Air-Supplied Airline Full Facepiece Respirators
- Disposable Protective Suits and Boots
- Permeation Resistant Rubber Gloves



Isocyanate Samplers

- Large Tent
  - 2 Personal samples (Sprayer and Hose handler)
  - 5 Area samples (2 inside tent, 1 outside tent, 2 in/by trailer)

- Small Tent
  - 2 Personal samples (Sprayer and Hose handler)
  - 5 Area samples (2 inside tent, 1 outside tent, 2 in/by trailer)

Isocyanate Samplers

- Vertical Wall – First Coat
  - 2 Personal samples (in Cherry Picker)
  - 7 Area samples (1 on top of tunnel, 1 in cherry picker, 5 out from wall)

- Vertical Wall – Second Coat
  - 2 Personal samples (in Cherry Picker)
  - 7 Area samples (2 on top of tunnel, 4 out from wall, 1 by trailer)

Exposure Criteria for MDI

- Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit
  - 0.2 milligrams MDI per cubic meter of air (mg/m^3)
  - This is a ceiling limit, not to be exceeded at any time
- American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs)
  - 0.051 mg/m^3
  - This is an eight-hour value, time weighted averaged (TWA) over the course of one workday
- These are conditions under which nearly all workers can be exposed without adverse effects

Large Tent Study Results

Sample	*MDI (mg/m³)*
Personal – Sprayer	0.21
Personal – Hose Handler	0.99
Area – Inside Tent – 20 Feet From Spray	0.52
Area – Inside Tent – Opposite End	0.20
Area – Outside/Downwind of Tent	< 0.005
Area – Inlet of Air Vent into Trailer	< 0.005
Area – Inside Trailer	< 0.005
ACGIH Threshold Limit Value (TWA basis)	0.051
OSHA Ceiling Limit	0.2

Small Tent Study Results

Sample	*MDI (mg/m^3)*
Personal – Sprayer	0.58
Personal – Hose Handler	2.2
Area – Inside Tent – Between Two Spray Areas	2.1
Area – Inside Tent – Opposite End	1.5
Area – Outside of Tent	< 0.01
Area – Inside Trailer	< 0.01
Area – Inside Trailer	< 0.01
ACGIH Threshold Limit Value (TWA basis)	0.051
OSHA Ceiling Limit	0.2

Vertical Wall – First Coat Results

Sample	*MDI (mg/m^3)*
Personal – Sprayer (in Cherry Picker)	0.11
Personal – Sprayer (in Cherry Picker)	0.079
Area – On Top of Wall – 25 Feet Downwind	0.14
Area – 35 Feet From Wall, Behind Spray Unit	0.004
Area – Attached to Cherry Picker	< 0.005
Area – 20 Feet From Wall, 30 Feet Downwind	< 0.005
Area – 12 Feet From Wall, 65 Feet Downwind	< 0.005
Area – 20 Feet From Wall, 30 Feet Upwind	< 0.005
Area – 12 Feet From Wall, 65 Feet Upwind	< 0.005
ACGIH Threshold Limit Value (TWA basis)	0.051
OSHA Ceiling Limit	0.2

Vertical Wall – Second Coat Results

Sample	*MDI (mg/m^3)*
Personal – Sprayer (in Cherry Picker)	0.27
Personal – Sprayer (in Cherry Picker)	0.23
Area – On Top of Wall – Near Edge, 25 Feet Downwind	0.044
Area – On Top of Wall – 55 Feet Back From Edge	0.013
Area – 20 Feet Out From Wall, Near Ground Level	0.094
Area – 25 Feet Out From Wall, Near Ground Level	0.034
Area – 40 Feet Out From Wall, Near Ground Level	0.057
Area – 65 Feet Out From Wall, Near Ground Level	0.009
Area – Outside Control Trailer, by Door	< 0.006
ACGIH Threshold Limit Value (TWA basis)	0.051
OSHA Ceiling Limit	0.2

Personal Samples - Air Monitoring Results Summary

- Personal sample results, on four samples collected on sprayers and hose handlers working in tents on top of tunnel sections, ranged from 0.21 to 2.2 mg/m^3. All of these samples were in excess of both the ACGIH Threshold Limit Value and the OSHA Ceiling Limit. Appropriate PPE was required.
- Personal sample results, on four samples collected on sprayers working from a cherry picker to coat the vertical sides of tunnel sections, ranged from 0.079 to 0.27 mg/m^3. The two on personal during application of the second coat exceeded the OSHA Ceiling Limit. All four exceeded the ACGIH TLV. Appropriate PPE needed

Area Samples - Top of Tunnel
Air Monitoring Results Summary

- Area sample results, on four samples collected inside the tents on top of tunnel sections, ranged from 0.20 to 2.1 mg/m^3. Three were in excess of the OSHA Ceiling Limit, all exceeded the ACGIH Threshold Limit Value.
- Two area samples collected outside of the tents showed no detectable MDI (< 0.01 mg/m^3).
- Three area samples collected in, and one just outside of, the trailer in which the sprayed product is mixed and which houses the system feeding fresh air to the air-supplied respirator, showed no detectable MDI (< 0.01 mg/m^3).

Area Samples - Vertical Wall of Tunnel
Air Monitoring Results Summary

- Fourteen area samples were collected around the vertical wall spraying operation, seven during application of each of the two coats.
- Six of these showed no detectable MDI (< 0.01 mg/m^3).
- MDI levels on the other eight ranged from 0.004 to 0.094 mg/m^3. Of those with measurable MDI, none exceeded the OSHA Ceiling Limit while two exceeded the ACGIH TLV.

Spray Coatings Recommendations

- An air supplied respirator, such as the air-line units used during the spray application part of this study, and disposable suits provide adequate protection for the spray application worker doing similar type work.

- Other workers should not enter active spray application areas or areas where spraying has been discontinued but visual airborne coating overspray remains.

Spray Coatings Recommendations (continued)

- Based on measurements collected during this survey, workers any closer than 65 feet on the downwind side to open air spray operations should have the same personal protective equipment, including respirators, as the spray applicators during active spraying or when visual overspray still remains following spraying, unless there is a physical barrier between them and the spray area


Todd