



Diphoterine® vs Water in Chemical Decontamination

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Water Decontamination: A Critical Review – Introduction

☀ >25,000 Chemical Agents Can Cause Burns

- ☀ Acids
- ☀ Bases
- ☀ Oxidizing Agents
- ☀ Reducing Agents
- ☀ Others

Water Decontamination: A Critical Review – Scope of the Problem

☀ France 1984

- ☀ 7,000 Serious Occupational Chemical Burns (about 50% involved the eyes)
- ☀ 120,000 Lost Work Days
- ☀ 250 Cases of *Permanent Disability*

Water Decontamination: A Critical Review – Scope of the Problem

- ★ USA, 2002 (Poison Center Data):
 - ★ 2,380,028 Total Human Poison Exposures
 - ★ 193,822 *Dermal* Exposures
 - ★ 130,857 *Eye* Exposures

Water Decontamination: A Critical Review – Scope of the Problem

- ★ USA, 2001 (Bureau of Labor Statistics, US Department of LABOR):
 - 5,900 Occupational Deaths
 - 8.5% (502 Deaths) Due to “Exposure to Harmful Substances or Environments”
 - 68,269 Non-Fatal Occupational Injuries Due to “Exposure to Harmful Substances or Environments”
 - 25,125 Involved Exposure to “Chemicals and Chemical Products”
 - 9,541 Non-Fatal Chemical Burns

Water Decontamination: A Critical Review – Standard Recommendations

★ Water! Water! Water!

- ★ Remove Contaminated Clothing (Decreases Skin Contamination by *up to 80%*)
- ★ Add Soap if the Chemical is *Lipid Soluble* (Skin Only)

★ ANSI Z358.1-1998 Standard

- ★ *Emergency Showers: 75.7 L/min*
- ★ *Emergency Eyewash Stations: 7.5-13.25 L/min*



Water Decontamination: A Critical Review – Materials and Methods

★ In-Depth Searches of Published Literature and Appropriate Websites for:

★ Scope of the Problem Data

- Frequency of Chemical Burns
- Involved Chemicals
- Reasons for Exposure

★ Evidence for Water Decontamination Efficacy

- Clinical Outcome
- Type of Initial Decontamination
- Delay to Decontamination

Water Decontamination: A Critical Review – Results

☀ Types of Information Retrieved and Reviewed:

- Occupational Burn Information from Governmental Agencies or Assembled from Government Sources
- Burn Center/Unit Data
- Experimental Animal Studies
- Older Human Case Reports
- More Recent Human Case Reports
- Case Series/Epidemiological Studies

Water Decontamination: A Critical Review – Results

- ✦ Occupational Burn Information from Governmental Agencies or Assembled from Government Sources
 - From the UK, Switzerland, Taiwan, and various States in the US
 - Working-Age Patients/Work-Related Burn Admissions are Common
 - Hospital/Burn Center-Unit Admission is Common
 - Surgical Treatment often Required
 - Costs can be *Significant* (i.e., 17.7 M Swiss Francs in 1 Year; \$US 5 M Annually in Washington State Alone)
 - *Lost Work Time* may be Prolonged (Up to 132 Days for Hospitalized Patients in One Study)



Water Decontamination: A Critical Review – Results

✶ Burn Center/Unit Data

✶ Canada, Toronto

- ✶ 24 Patients with Chemical Burns (2.6% of Admissions)
- ✶ 75% Work-Related
- ✶ 14/24 Required *Extensive Excision and Skin Grafting*
- ✶ 58% had *Significant Complications*
- ✶ 1 Patient *Died*
- ✶ Early Water Decontamination was Associated with Better Outcome, but *Did Not Prevent Burns and Significant Complications*

Water Decontamination: A Critical Review – Results

✶ Burn Center/Unit Data

✶ India, Chandigarh

- ✶ 27 Patients with Chemical Burns (4.8% of Admissions)
- ✶ Mainly *Skin* splashes, but *Eye* Involvement in 74%
- ✶ *Vision Loss* in 2 Patients
- ✶ *All Burns were Infected* by 4 weeks after injury
- ✶ 1 Patient Developed *Invasive Sepsis*
- ✶ Water Decontamination *did not prevent* these complications

Water Decontamination: A Critical Review – Results

✶ Burn Center/Unit Data

✶ USA, Boston

- ✶ 35 Patients had Chemical Burns (4% of Admissions)
- ✶ 51% were *Work-Related*
- ✶ *Immediate* Water Decontamination was Associated with *Less Full-Thickness Burns* and *Fewer Hospital Admission Days*, ***BUT***
- ✶ Immediate Water Decontamination *did not Prevent Burns*:
 - 16 Patients were Hospitalized for a Mean of 7.7 Days
 - 12.5% had Full-Thickness Burns

Water Decontamination: A Critical Review – Results

✶ Burn Center/Unit Data

✶ USA, Iowa City

- 97 Patients with Chemical Burns (3.3% of Admissions)
- 31/94 (34%) from *Anhydrous Ammonia*
- *Majority were Work-Related*
- *1 Fatality*
- 36/94 (38%) Required *Skin Grafting*
- Early and Prolonged Water Decontamination *did NOT Prevent Serious Burns and Death*



Water Decontamination: A Critical Review – Results

✶ Experimental Animal Studies

- ✶ *Few Studies*
- ✶ *Methodological Problems* (Few Animals, Exposure Routes, etc.)
- ✶ Identified Studies Done: 1927, 1962, 1975(2), 1993, 1994, 2003
- ✶ Issue of Neutralization of Chemicals Re-emerging



Water Decontamination: A Critical Review – Results

- ✱ Older Human Case Reports (1943, 1959)
 - ✱ Neutralization *might* decrease the severity of corrosive chemical burns
 - ✱ Extensive burns, systemic toxicity, and *death* may *not* be prevented by early and prolonged water decontamination



Water Decontamination: A Critical Review – Results

☀ More Recent Human Case Reports I

- ☀ Sodium Hydroxide Oven Cleaner: Rinsing with a water-Moistened Cloth did *Not* prevent Need for Full Thickness Burns or Skin Grafting
- ☀ Caustic Lime-Pit Exposure: Hubbard Tank Water Decontamination did *NOT* Prevent Need for Skin Grafting
- ☀ In 2 of 3 Cases of Caustic Soda Burns: Deep Necrotic Burns of the Hands and Feet, Requiring Debridement and Skin Grafting

Water Decontamination: A Critical Review – Results

☀ More Recent Human Case Reports II

- ☀ Sodium Hydroxide Spill: 53% TBSA Burn and Requirement for Debridement, Skin Grafting, and 43 Days Hospitalization *Despite* Immediate Copious Water Decontamination
- ☀ Titanium Chloride Splashes: *Despite Dry Wiping and Water Safety Shower Decontamination*, 2 Workers had 18 & 20% TBSA Burns (1 with Bilateral Corneal Burns), Requiring Debridement and Skin Grafting
- ☀ Up to 8 Weeks Lost Work Time

Water Decontamination: A Critical Review – Results

★ Saudi Arabian Children – Sulfuric Acid (7 Cases)

- Sulfuric Acid Skin Exposure
- 3-60% TBSA Burns
- Contaminated Clothing Removal and Water Decontamination Delayed by about ½ Hour
- Children with 10, 15, and 60% TBSA Burns Admitted to Hospital
- Child with 60% TBSA Burns
 - 166 Days Initial Hospitalization
 - 9 Surgical Procedures

Water Decontamination: A Critical Review – Results

☀ More Recent Case Reports

☀ River Barge Workers – Anhydrous Ammonia

- 2 Workers
- Disconnected Anhydrous Ammonia Hose
- Immediate Change of Contaminated Clothing and Water Shower -> Less Severe Burns
- Did *NOT* Prevent Burns



Water Decontamination: A Critical Review – Results

★ Case Series/Epidemiological Studies

- ★ **51 Patients:** Water Decontamination did *NOT* Prevent Burns or *9.5% Mortality*
- ★ **273 Patients:** Water Decontamination did *NOT* Prevent *Hospitalization* or Need for *Skin Grafting*
- ★ **111 Chemical Burn Patients:** *5.4% Mortality*
- ★ **87 Chemical Burn Patients:** 30 had *Significant Complications*
- ★ **Chemical Exposure Caused 27/104 Ocular Burn Injuries** in One Case Series



Water Decontamination: A Critical Review – Conclusions

- ✱ Chemical Burns Represent a Small Portion of All Burn Injuries, *BUT*
 - ✱ *Human and Economic Impact is Significant*

Water Decontamination: A Critical Review – Conclusions

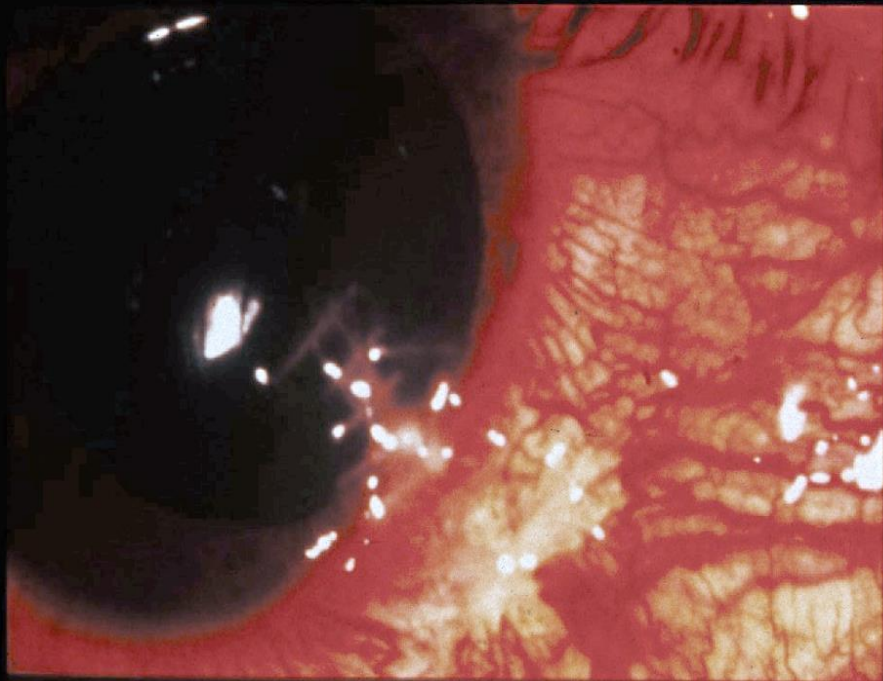
☀ Water Decontamination *Can*:

- ☀ Decrease Severity of Skin/Eye Chemical Burns
 - *Sooner and Longer* Water Decontamination seems to be *Better*

Water Decontamination: A Critical Review – Conclusions

★ Water Decontamination *Cannot Always:*

- ★ Prevent *Burns*
- ★ Prevent *Lost Work Time*
- ★ Prevent Need for *Hospitalization*
- ★ Prevent Need for *Surgical Treatment*
- ★ Prevent *Complications*
- ★ Prevent *Sequelae*













Water Decontamination: A Critical Review – Conclusions

★ Since Water! Water! Water! Is ***NOT*** the *Final Answer* to Skin/Eye Chemical Splashes, a Replacement Decontamination Solution Should be:

- ★ Sterile
- ★ Chelating
- ★ Polyvalent
- ★ Amphoteric
- ★ Non-Toxic
- ★ Hypertonic
- ★ Water-Soluble

DIPHOTERINE®

★ For *ACTIVE* Skin/Eye Decontamination

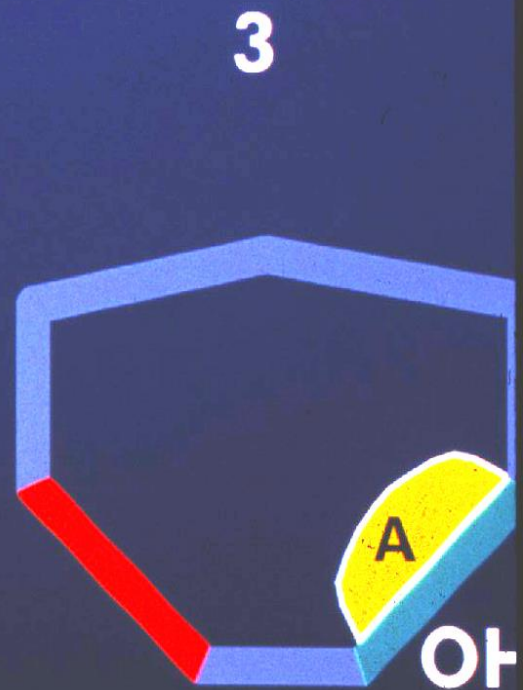
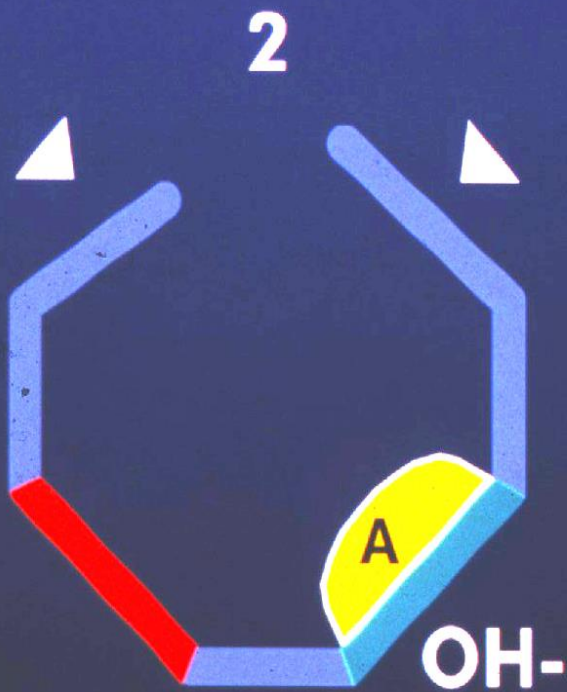
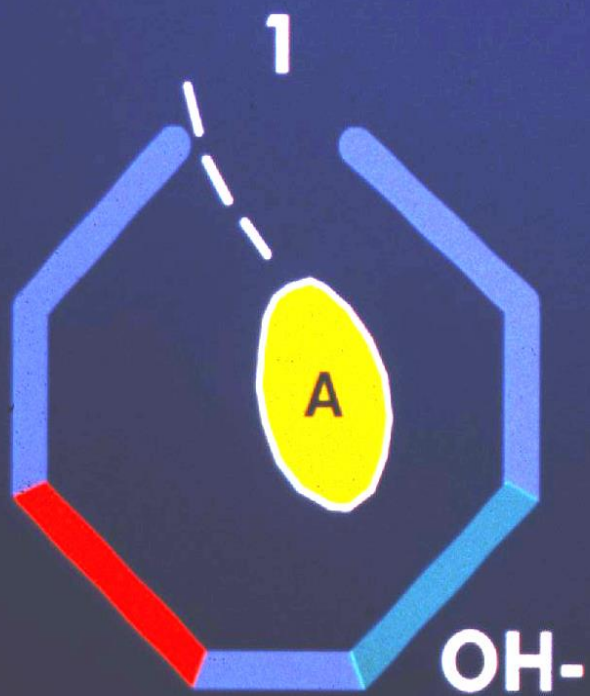
- ★ Sterile
- ★ Chelating
- ★ Polyvalent (6 binding sites)
- ★ Amphoteric
- ★ Non-Toxic ($LD_{50} > 2,000$ mg/kg)
- ★ Hypertonic
- ★ Water-Soluble
- ★ Non-Irritant (also acid/base decontamination residues)
- ★ Reactions *not* significantly exothermic
- ★ Nearly immediate pain relief

DIPHOTERINE®

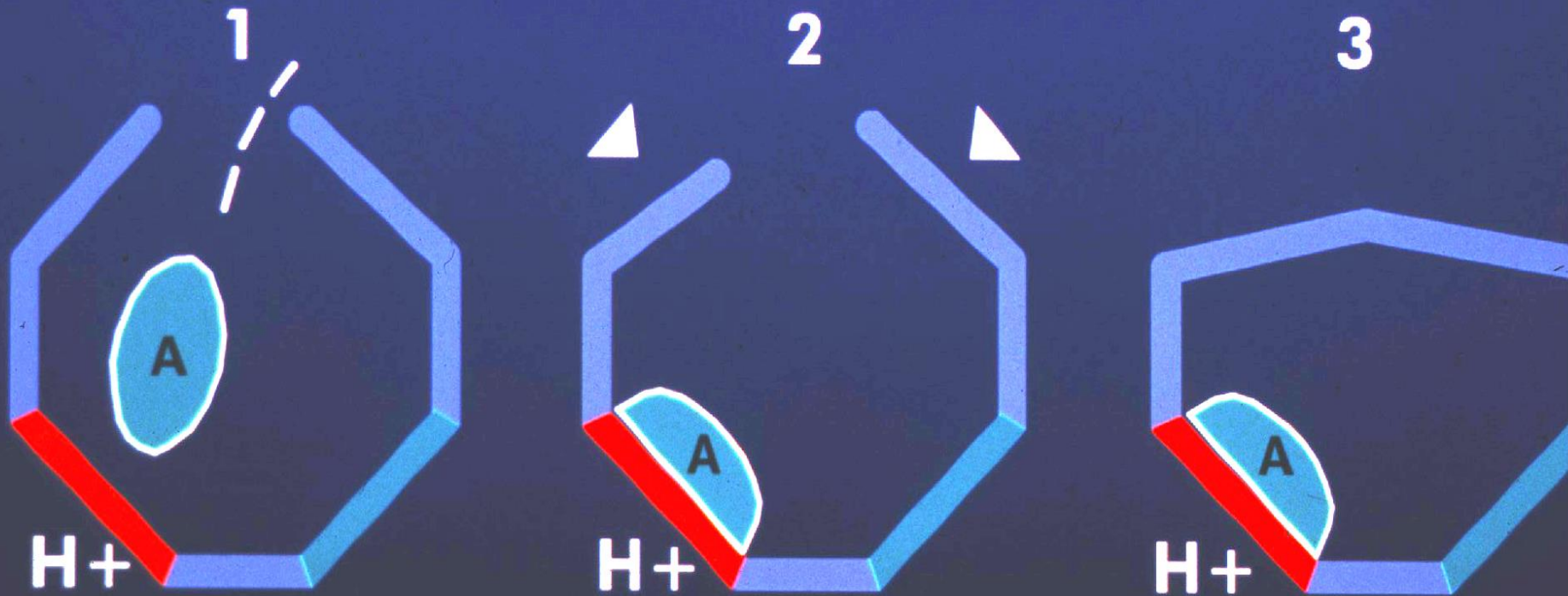
- ★ Effective for Skin/Eye Decontamination of:
 - ★ Over 600 Chemicals/Chemical Groups (European experience with >600 industrial cases)
 - Acids
 - Bases
 - Oxidizers
 - Reducing Substances
 - Alkylating Agents
 - Irritants/Lacrimators
 - Solvents

Therefore, useful for UNKNOWN CHEMICAL EXPOSURES

DIPHOTERINE and Acids



DIPHOTERINE and Alkalies



Burns on legs from sulphuric acid at 94 %



```
graph TD; A[Burns on legs from sulphuric acid at 94 %] --> B[Washed with water]; B --> C[6 1/2 months off work]; C --> D[Functional side effects];
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Washed with water

6 1/2 months off work

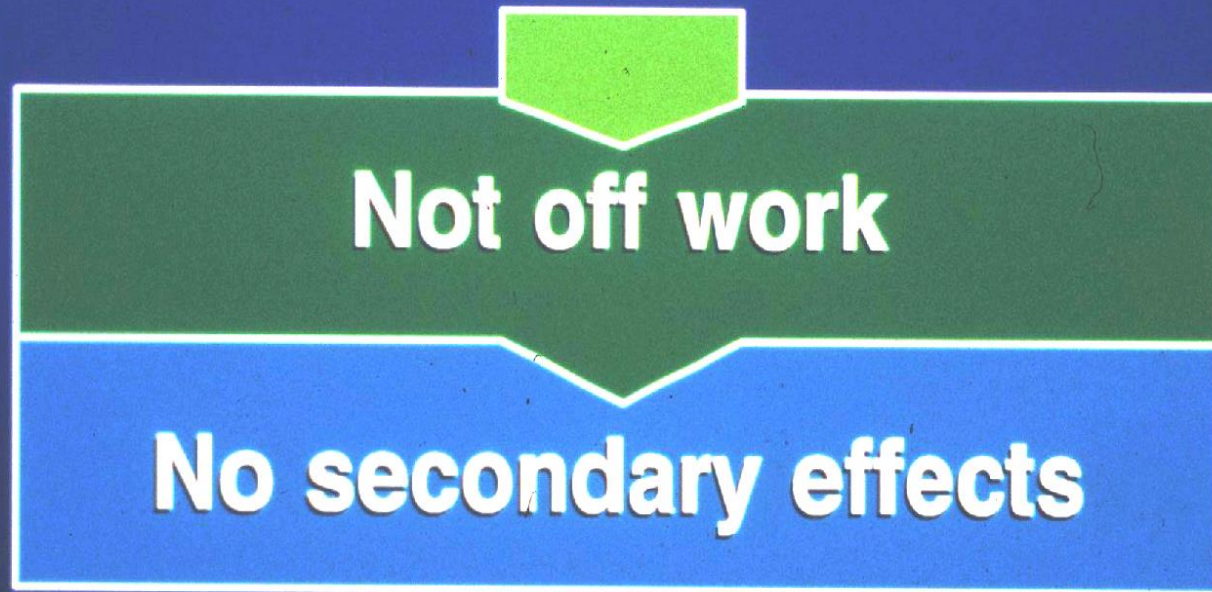
Functional side effects

La QUINOLEINE, France

2 works burnt with sulphuric acid at 95 % on

- **face**
- **neck**
- **legs**
- **shoulder**

Undressed and washed with Diphoterine



I.N.R.S.

Diphoterine

- ➡ **Reduces the seriousness of the accident**
- ➡ **Stops the pain**

**The recommended dose should
always be used**

**24 CASES OF ACID/BASE EYE/SKIN EXPOSURE
IN WORKERS AGED 21 - 62 YEARS
AT THE MANNESMANN HOESCH PRAZISROHR FACILITY,
REMSCHIED, GERMANY, 1994-8**

INVOLVED PROCESSES:

- **Degreasing**
 - **Neutralization**
 - **Transferring solid/liquid chemicals**
 - **Stripping**
 - **Suctioning**
 - **Cleaning**
 - **Placing pipes in chemical bath**
 - **Contact with spilled chemical**
-

Splash Types

Splash Type	Eye	Skin
Acid	11	8
Base	4	1

Ocular Acid Splashes

Product	Concentration	Eye	Initial Lavage	Secondary Lavage	Additional Treatment	Lost Work Time (days)	Sequelae
Mixture $\text{H}_3\text{PO}_4/\text{HNO}_3$	H_3PO_4 5% / HNO_3 30-35%	Left	Diphoterine®	Diphoterine®	None	0	None
H_2SO_4	20%	Right	Diphoterine®	Diphoterine®	None	0	None
$\text{NH}_2\text{SO}_3\text{H}$	Powder	Right	Diphoterine®	Diphoterine®	None	0	None
H_2SO_4	20%	Not Reported	Diphoterine®	Diphoterine®	None	0	None
$\text{NH}_2\text{SO}_3\text{H}$	Powder	Not Reported	Diphoterine®	Diphoterine®	None	0	None
H_2SO_4	20%	Right	Diphoterine®	Diphoterine®	None	1	None
Mixture $\text{H}_3\text{PO}_4/\text{HNO}_3$	H_3PO_4 5% / HNO_3 35%	Left	Diphoterine®	Diphoterine®	None	1	None
H_2SO_4	20% (dilute)	Left	Diphoterine®	Diphoterine®	None	0	None
Mixture $\text{H}_2\text{SO}_4/\text{HNO}_3$	5% H_2SO_4 / 7% HNO_3	Left	Diphoterine®	Diphoterine®	None	1	None
H_2SO_4	20%	Right	Diphoterine®	Diphoterine®	None	0	None
H_2SO_4	20%	Left	Diphoterine®	Diphoterine®	None	0	None

Acid Skin Splashes

Product	Concentration	Body Area	Initial Lavage	Secondary Lavage	Additional Treatment	Lost Work Time (days)	Sequelae
HNO ₃	53%	Head	Diphoterine®	Diphoterine®	None	0	None
H ₂ SO ₄	20%	Right Cheek	Diphoterine®	Diphoterine®	None	0	None
H ₂ SO ₄	20%	Thorax	Diphoterine®	Diphoterine®	None	0	None
H ₃ PO ₄	16%	Left Forearm	Diphoterine®	Diphoterine®	None	0	None
H ₂ SO ₄	20%	Face	Diphoterine®	Diphoterine®	None	0	None
H ₃ PO ₄	15%	Right Hand	Diphoterine®	Diphoterine®	None	0	None
H ₃ PO ₄	75%	Thorax, Genitals, Right Thigh	Diphoterine®	Diphoterine®	None	0	None
H ₂ SO ₄	20%	Right Hand	Diphoterine®	Diphoterine®	None	0	None

Ocular Base Splashes

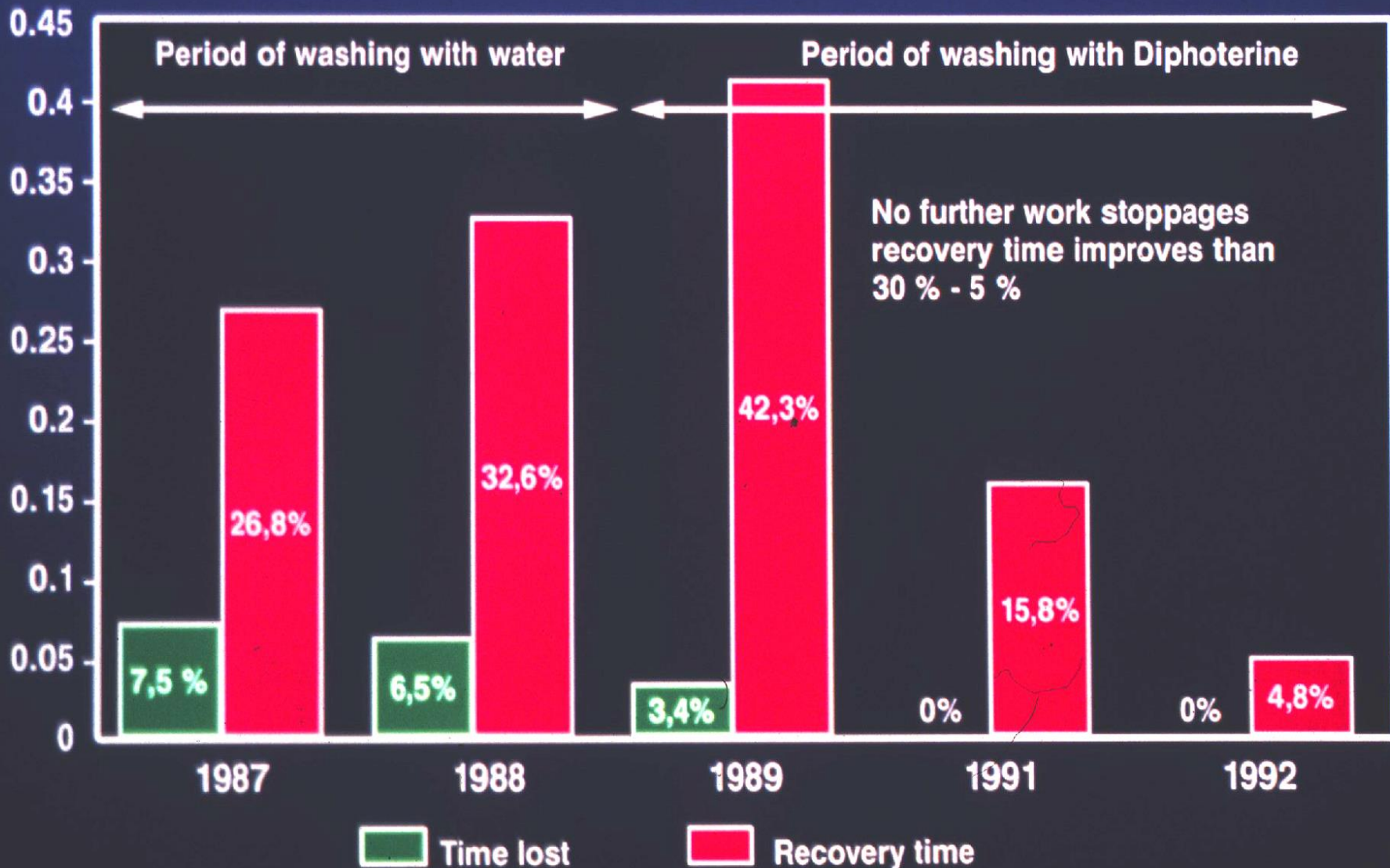
Product	Concentration	Eye	Initial Lavage	Secondary Lavage	Additional Treatment	Lost Work Time (days)	Sequelae
Sodium Hydroxide	30%	Right	Diphoterine®	Diphoterine®	None	0	None
Basic Solution	30%	Right	Diphoterine®	Diphoterine®	None	0	None
Quicklime (Calcium Oxide)	Unknown	Right	Diphoterine®	Diphoterine®	None	0	None
Quicklime (Calcium Oxide)	Unknown	Left	Diphoterine®	Diphoterine®	None	0	None

Base Skin Splashes

Product	Concentration	Body Area	Initial Lavage	Secondary Lavage	Additional Treatment	Lost Work Time (days)	Sequelae
Sodium Hydroxide	45%	Knee	Diphoterine®	Diphoterine®	None	0	None

Comparison of Diphoterine / Water

1987 - 1988 : Water / 1989 - 1991 : Diphoterine



375 Cases of Skin/Eye Chemical Splashes

ELF Atochem Plant, Saint-Avoid, France

★ 5 *Priority Chemicals:*

- Acrylates (methyl, ethyl, butyl)
- H_2SO_4 (98%)
- Oleum
- NaOH (22%, 5.5 M)
- Diethylaminoacrylate (ADAME)

ELF Atochem Study

LOST WORKTIME

Decontamination	Water	Diphoterine®
With Lost Worktime	7 (3.4%)	0 (0%)* *(p <0.05)
Without Lost Worktime	198	170

ELF Atochem Study

SEQUELAE

Initial decontamination	Water	Diphoterine®
Total Cases (N)	205	170
No Sequelae	68 (33%)	88 (52%)* *(p <0.05)
With Sequelae	137	82

ELF Atochem Study

OPHTHALMOLOGICAL CONSULTATION

* (about 50% less Ophthalmological Consultations when Diphoterine® was the initial decontaminant instead of water)

Decontamination	Water	Diphoterine®
Without Ohthalmological Consultation	32	19
With Ophthalmological Consultation	11 (26.5%)	3 (13.6%)*

ELF Atochem Study

BURN CENTER CONSULTATION

*(2/3 less Burn Center Consultations when Diphoterine® was the initial decontaminant instead of water)

Decontamination	Water	Diphoterine®
Without Burn Center Consultation	153	145
With Burn Center Consultation	9	3*

Personnel Protection

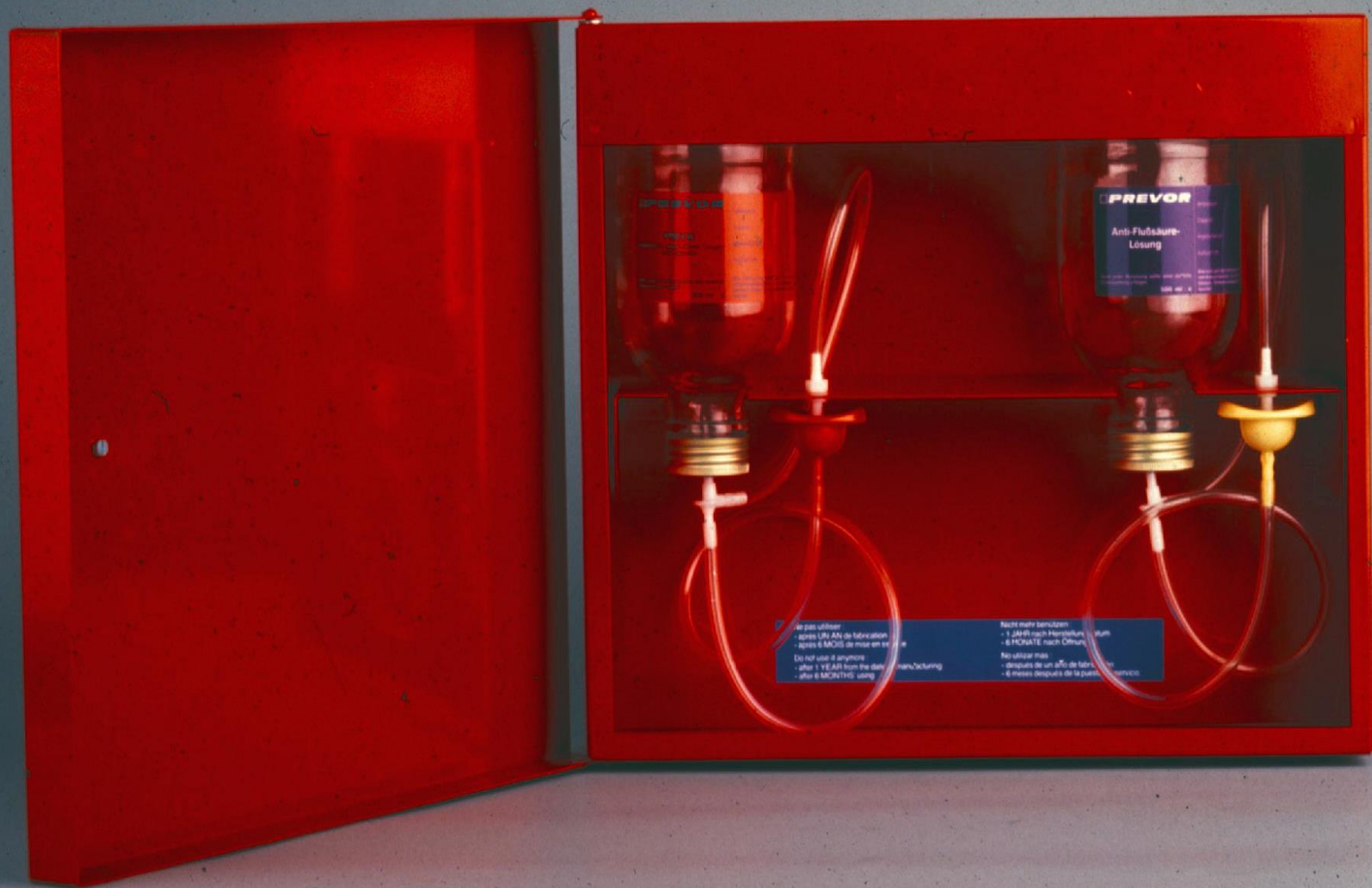












COMPATIBLE WITH ALL

PREVOR

Anti-Fluorescence

Lösung

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- after 1 year from the date of manufacture
- after 6 months of use

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Diphoterine

- ★ An *active* eye/skin decontamination compound with *demonstrated efficacy* for *nearly all types* of chemical exposures
- ★ Should be considered as a *potentially more efficacious* alternative to water decontamination