



# CHEMICAL SPLASHES



**DIPHOTERINE®**



**HEXAFLUORINE®**

## PRINCIPLES AND INDICATIONS FOR USE

*Why use Diphoterine® or Hexafluorine®?*

**AN EMPLOYEE HAS BEEN SPLASHED WITH A CHEMICAL  
AND  
HAS BEEN DECONTAMINATED WITH DIPHOTERINE® OR HEXAFLUORINE®**

- To stop the chemical's action on the eye or skin and to easily remove it
- To increase effectiveness in comparison with washing with water or saline solution:
  - \* Improved intervention time for optimal efficacy use within one minute as opposed to 10 seconds for water washing
  - \* Effective for binding a wide variety of different chemical substances
  - \* Decreases requirements for care beyond initial decontamination, sequelae and lost work time
  - \* For hydrofluoric acid: simultaneous action on both its corrosiveness and toxicity
  - \* In the event of delayed washing:
    - Diphoterine® stops the chemical's harmful effects,
    - has a positive effect on the healing time, facilitating patient management

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Toxicology Laboratory & Chemical Risk Management



# ACKNOWLEDGEMENTS

## WE THANK :

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for their participation in the writing and editing of this document.



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# THE MECHANISM AND MANAGEMENT

## OF CHEMICAL BURN INJURIES

### 1.1 – FACTORS DETERMINING THE SEVERITY OF CHEMICAL BURNS

➤ Chemical burns are the result of a chemical reaction between a corrosive or irritating molecule and one or more biochemical components of the skin or eye.

The severity of a chemical burn depends mainly on:

- nature and concentration of the chemical,
- energy of the reaction,
- duration of contact.

It also depends on physical factors such as the involved pressure or the temperature, the area and the extent of the affected tissues and whether the tissues are healthy or not. The effectiveness of emergency decontamination and first aid care influence the appearance and the development of the chemical burn and consequently, the significance of the sequelae (1) ■

### 1.2 – SPEED AND EFFECTIVENESS OF WASHING CHEMICAL SPLASHES

➤ It is well-known, by all professionals in the field of prevention and safety, that the early washing of a chemical splash makes it possible to decrease the severity of the burn. Historically, water was the obvious universal means of decontamination. This was a great advance in limiting the severity of chemical burn lesions (2). However, this progress was limited by two factors:

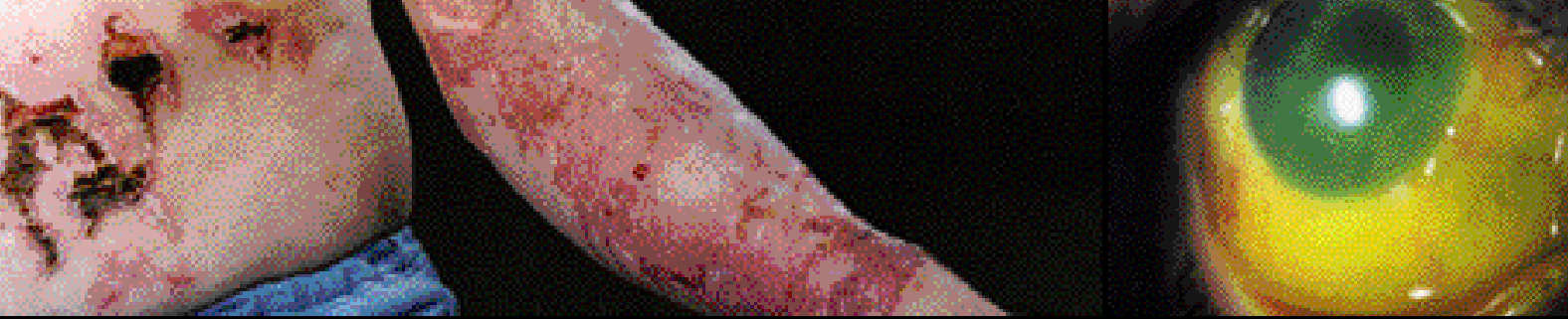
- time it takes to intervene and thus the duration of chemical contact,
- concentration of the major corrosive agents (3).

This very short recommended intervention delay of about 10 seconds, is, in practice, difficult to achieve at the time of the accident which can lead to worsening of the lesions caused by a corrosive agent.

Study and the elucidation of the mechanism of the chemical burn (Figure 1) has led the PREVOR® Laboratory to conceive solutions for “active washing”, which can be considered as improvements on washing with water. **An amphoteric molecule with multiple binding sites, capable of reacting with corrosive and irritating agents and preventing or decreasing their action on the tissues was added to the effects of mechanical washing and passive dilution provided by water decontamination.** The types of chemicals which result in chemical burns are acids, bases, oxidising agents, reducing agents, chelating agents, alkylating agents and certain solvents.

The active washing solution is also hypertonic, which interrupts the penetration of a corrosive or irritating agent into the tissue. The purpose of active washing, with solutions such as Diphoterine® and Hexafluorine®, is to prevent or decrease the after-effects of chemical burns ■





# CHEMICAL BURNS

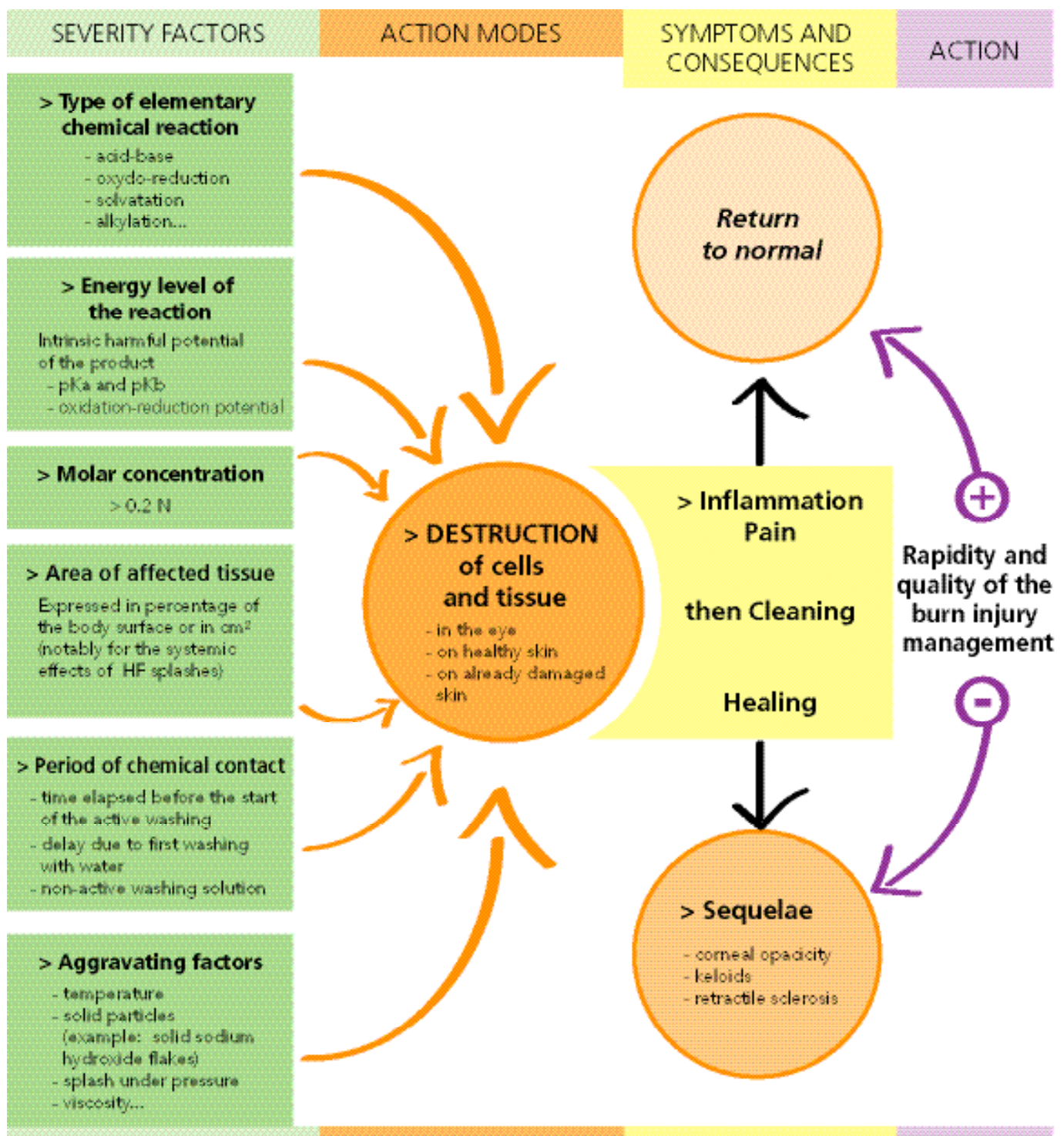


Figure 1: chemical burn injuries and aggravating factors



## 2.1 – DIPHOTERINE®'S MECHANISM OF ACTION

➤ Diphoterine® is a general-purpose washing solution for ocular and cutaneous chemical splashes. Diphoterine® is a **hypertonic**, **amphoteric** and **multi-site** washing solution.

It therefore has a double effect:

- **mechanical properties of washing with water**
- **additional neutralising and chelating properties** which accelerate and optimise the process of decontamination.
- The hypertonicity of Diphoterine® prevents the chemical from penetrating the tissue and makes it possible to create a reverse flux capable of pulling the chemical out of the tissue.
- Its amphoteric character and its various reactive sites enable it to act on the irritating and corrosive agents which cause chemical burns. These include acids, bases, oxidising agents and reducing agents... ■

## 2.2 – WASHING WITH DIPHOTERINE®: ADVANTAGES COMPARED TO WATER

➤ As with water, the purpose of using Diphoterine® rapidly is to attempt to prevent chemical burns. The more rapidly Diphoterine® is used, the shorter the contact with the chemical will be. The risk of a chemical burn occurring will thus be minimised.

Concerning the action performed on the corrosive substance, Diphoterine®, compared to water, neutralises the aggressive nature of the chemical (acid, base, oxidant, reducer or chelator) much more rapidly and effectively with less washing ■

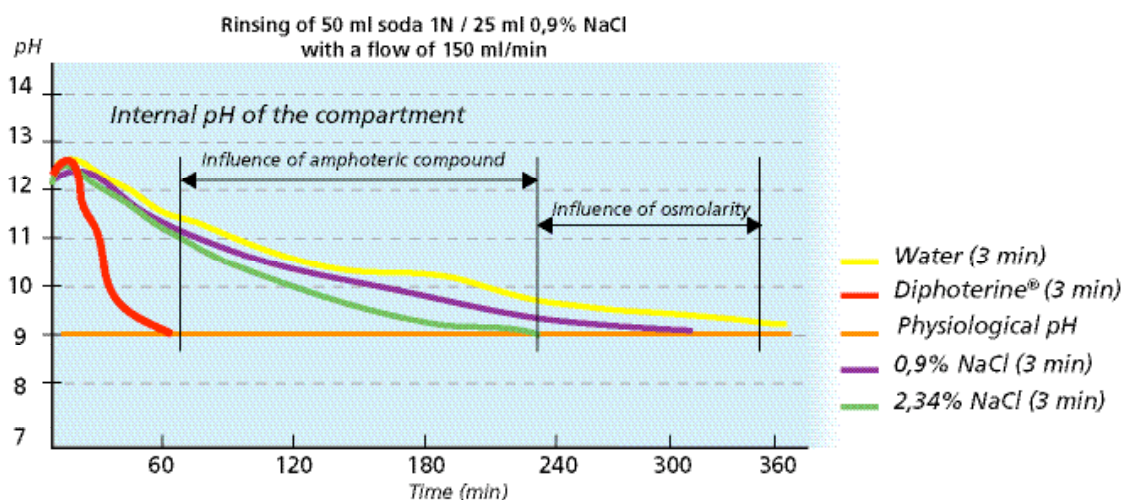


Figure 2: Influence of osmotic pressure and amphoteric properties on washing effectiveness



## DIPHOTERINE®

➤ Diphoterine®'s effectiveness has been proven on an experimental and a clinical level. The analysis of these data concerning chemical decontamination with Diphoterine® is based on three levels of scientific evidence.

### • Convergent clinical data:

In spite of the difficulties of performing studies on first aid in the workplace and the inevitable limitations related to the interpretation of the results, much of the data collected on human subjects provide convergent elements.

Many accounts of Diphoterine® use have been provided by companies (1). Generally transmitted by occupational health doctors, the reports can be criticised one by one, either for a problem of methodology or interpretation, but when all of these **several hundred cases of Diphoterine® use** are combined, the coherence of the whole reveals some certainties about its effectiveness:

- no harmful effects,
- decrease in pain,
- no after-effects,
- absence of or only a small amount of secondary care,
- absence of or only a few days of work loss.

The French National Institute of Research and Safety decided to independently verify the effectiveness of various chemicals splash decontamination methods, including Diphoterine®. For that purpose, an investigation (2) was carried out with the help of company medical doctors in France. 73 companies and more than 60 accidents were taken into consideration. This study shows Diphoterine®'s action on a varied sample of chemicals, and indicates that Diphoterine®, when used according to the recommended protocol, is always at least as effective as water. The continuation of this investigation (3) showed that the results, for a total of 145 chemical splash cases studied, were superior for concentrated bases. In the study performed by Martinswerk (1), the superiority of Diphoterine® washing on bases, both in terms of effectiveness and washing safety, was also confirmed despite the small size of the statistical series:

Washing Solution	Diphoterine®	Acetic Acid	Water
No secondary care	100 % +/- 15	0 % +/- 15	0 % +/- 15
Simple secondary care	0 % +/- 15	80 % +/- 15	25 % +/- 15
Medicalised secondary care	0 % +/- 15	20 % +/- 15	75 % +/- 15
Number of days of work loss	0.18 % +/- 0.4	2.91 % +/- 4.3	8 % +/- 8.12

$p < 0.05$

For isolated reported cases, the examples are also very significant. Take the case of 2 large cutaneous splashes of concentrated sulphuric acid with equal concentrations (95%): the one washed with water led to serious after-effects, and six months of work loss, and the other washed with Diphoterine® resulted in neither after-effects nor work loss (4) ■

- **Experimental *in vivo* data which confirm the clinical results:**

When the chemical burn does occur, its development is determined by two phenomena:

- the cleaning phase (inflammation, destruction), which is increased in cases of chemical burns,
- the repairing phase (healing), which is decreased.

*In vivo* experimental studies have confirmed that when the development of the chemical burn is stopped, the healing of the injured tissues is carried out in better conditions. The effectiveness of washing with Diphoterine® was compared (8,9) to washing with saline solution on a concentrated cutaneous hydrochloric acid burn in rats. Diphoterine® stopped the development of the chemical burn, which led to the following consequences:

- **a significant reduction of pain** (reduction of concentrations of substance-P in the first 48 hours,  $p < 0.05$  ; increase of the concentration of  $\beta$ -endorphin after 7 days,  $p < 0.05$ ),
- **a reduction of inflammation** (reduction of the interleukin-6 after 48h,  $p < 0.01$ ; after 7 days,  $p < 0.05$ ),
- **better healing of the skin** (size of the lesion after 7 days : Diphoterine® 4 mm<sup>2</sup> versus saline solution 6 mm<sup>2</sup>, no washing 12 mm<sup>2</sup>).

A study of a 15.3% ammonia ocular burn in rabbits (10) has allowed an understanding of the chemical burn mechanism and has showed the relevance of even delayed treatment of such a burn. This experimental burn model was then tested in order to compare **the effectiveness of Diphoterine® versus saline solution** (11). After washing with Diphoterine® there is:

- **an absence of a stromal oedema**, while it has been observed after washing with saline solution or even when there is no washing,
- **an inflexion of the pH**, which has not been observed after washing with saline solution or when there is no washing.

The presence of a stromal oedema, resulting from inflammation due to the burn and the hypotonic effect of washing, is known to be an aggravating factor in the development of chemical burns (12) ■





• Experimental data ex vivo / in vitro which explain the clinical results:

These studies have allowed us to understand and confirm the clinical results obtained. One of these (13) compares the effectiveness of different washing solutions in exposure to 5ml of 0.5 M caustic soda or hydrochloric acid and shows the limitations of water washing on corrosive agents. Despite adding an amount of water which represented 50 times the amount of caustic soda or of hydrochloric acid contamination, water did not bring the pH level back to physiological values.

Chemical	Added Water (250 ml)	Added Diphoterine® (Previn®) (100 ml)
0.5M Caustic Soda	pH = 11.8	pH < 9
0.5M Hydrochloric Acid	pH = 2	pH = 6.3

Physiological zone (no burn): 5.5 < pH < 9

An experiment on enucleated pig eyes measured the effect of both early and delayed washing on the development of the intra-ocular pH: only washing with Diphoterine® showed an improvement of the intra-ocular pH, even if the washing was delayed.

In this same publication (13), the physical limits of water washing on fibroblast cultures is shown. Water is hypotonic. When there is a chemical burn, the osmotic pressure of the cornea increases up to 1280 mosmoles/kg. Washing with a hypotonic solution (such as water) can cause osmotic shock and a cytolysis (destruction of cells after swelling). See also the Kompa et al's publication (14) on the direct effect of a washing solution's osmolarity on the cornea's osmolarity.

The following table clearly shows the advantages of using Diphoterine® ■

WATER		DIPHOTERINE®	
Advantages	Limitations	Advantages	Limitations
Chemical agent(s) at the surface of the affected tissues are carried away		Chemical agent(s) at the surface of the affected tissues are carried away	
Dilution		Dilution	
Polyvalent		Polyvalent	Theoretical and experimental effectiveness proven on major chemical groups. Should be verified case by case for specific chemical agents
	Hypotonic Favours a part of the chemical agent's penetration of the tissue, especially in the eyes	Hypertonic Stops the chemical agent's penetration of the tissue and carries the chemical away from the interior to the exterior of the tissue	
	No action on corrosive or irritating agents <b>Development of the chemical burn</b>	"Neutralising" action on the potentially irritating or corrosive nature of the chemical agent <b>Stops the development of the burn</b>	
		Amphoteric <b>Allows a rapid return to a physiological pH</b>	
	<b>Optimal intervention time: the first 10 seconds</b>	<b>Optimal intervention time: within the first minute</b> 6 times superior Increased security of first aid	
	Possibility of serious physical after-effects, even death(3)	Decrease or absence of after-effects (compared to water) <b>Better prevention of chemical burns</b>	
	In certain cases, complex secondary treatment with reconstructive surgery (3)	Decrease or absence of secondary treatments <b>Prevents after-effects</b> Decrease in work loss	A medical consultation is necessary in every case
Non-toxic	Expiry date to be observed and weekly maintenance to be carried out	Non-toxic, sterile	Expiry date must be observed

A recent published study (15) shows the usefulness of Diphoterine® even in cases of delayed washing, within the first hours following an accident. The study compares, for equivalent grades of burns, the differences which occur after washing with Diphoterine® versus washing with saline solution before treatment of a burn due to an alkaline chemical. This study shows a significant reduction in the amount of time needed for the reepithelialization of the cornea:

Reepithelialisation time in days	Diphoterine®	Saline Solution	Value of p
Grade I	1.9 +/- 1	11.1 +/- 1.4	$p < 10^{-7}$
Grade II	5.6 +/- 4.9	10 +/- 9.2	$p < 0.02$
Grade III	20 +/- 14.1	45.2 +/- 23	$p = 0.21$ NS

*Absence of ocular Grade IV with Diphoterine®*

A published case (16) of a severe ocular chemical burn (Grade IV) shows the benefit of delayed washing with Diphoterine® and describes the associated secondary treatment, principally aimed at reducing inflammation and pain, as well as preventing infection. The case evolved towards progressive reepithelialization in less than 21 days, and complete stable healing in 180 days.

No surgical treatment was necessary in this case.

Summary of the advantages of using Diphoterine® over water or saline solution		
Results with Diphoterine®	Ocular (ammonia in rabbits (10,11))	Cutaneous (hydrochloric acid in rats (8,9))
<i>in vivo</i> versus saline solution	<ul style="list-style-type: none"> <li>- Decrease in corneal oedema</li> <li>- Reduction of the extraocular pH</li> <li>- Reduction of the intraocular pH</li> </ul>	<ul style="list-style-type: none"> <li>- Reduction of pain</li> <li>- Reduction of inflammation</li> <li>- Reduction in the time needed for tissue healing</li> </ul>
Clinical tests in industry (3) versus water	<ul style="list-style-type: none"> <li>- Decrease in requirement for care beyond initial decontamination</li> <li>- Decrease in lost work time</li> <li>- Decrease in after-effects</li> </ul>	
Clinical tests in hospitals (15,16) versus saline solution	<ul style="list-style-type: none"> <li>- Decrease in the time needed for healing</li> </ul>	

The advantage of Diphoterine® is that it acts directly on the corrosive or the irritating agents. This results in the prevention or minimisation of the inflammatory phenomena which occur very early in response to a cutaneous or ocular chemical splash. Hence the necessity, in order to achieve optimal effectiveness, of an immediate intervention at the site of the accident and of the presence of Diphoterine® as a first aid treatment at work stations ■



SIEW



► 50 ML FOR 1 EYE  
TO BE USED WITHIN  
THE FIRST 10 SECONDS

## 2 DIPHOTERINE®

### 2.3 – WHEN AND HOW SHOULD DIPHOTERINE® BE USED?

► Diphoterine® is indicated in first aid washing of all types of ocular and cutaneous chemical splashes.

It has a limited effect on hydrofluoric acid splashes because of both the corrosive and toxic mechanisms of this acid. It is preferable in these cases to wash with Hexafluorine®, which specifically addresses both of these problems.

Carried out within the first minute and using the entire amount in the appropriate product container, the purpose of external washing with Diphoterine® is to prevent or minimise the appearance of lesions and thus the risks ■

#### WASHING PROTOCOL WITH DIPHOTERINE®

**Wash** with Diphoterine® as the primary action and as rapidly as possible  
**within the first minute** for optimal efficacy

and

**remove clothing** and/or **contact lenses.**

**Continue washing,** being sure to use the entire contents of the  
Diphoterine® container. **Consult a specialist**

#### GENERAL INSTRUCTIONS

**Never delay washing**

**For optimal effectiveness, use Diphoterine®  
available at the site of the accident**

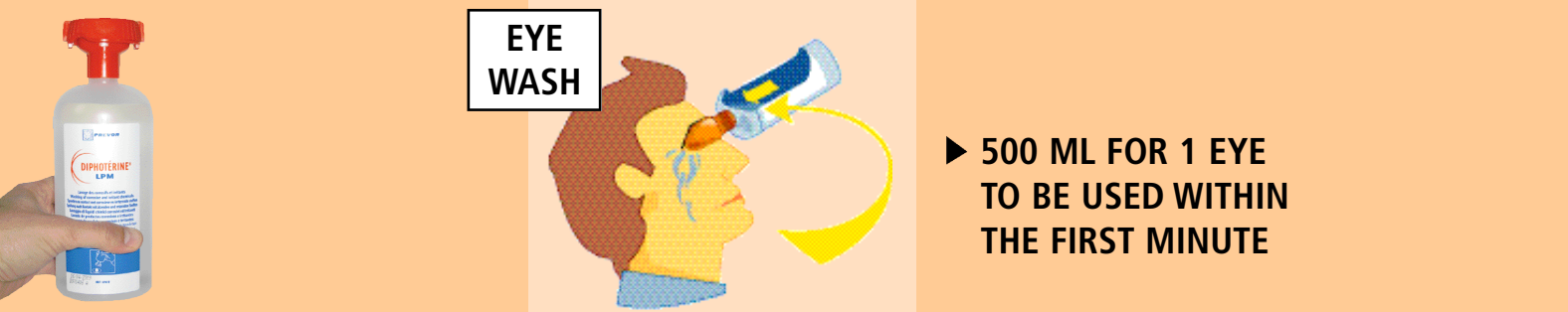
**If Diphoterine® is not available, use water and take the  
injured person to the hospital**

#### OCULAR WASHING:

► **Less than one minute of chemical contact requires 3 minutes of washing**, that is to say all the contents of a 500 ml bottle or a portable eyewash.

There is a minimal time period of about 10 seconds before the beginning of the chemical's penetration. For that reason, water can sometimes be effective, in particular with weak corrosive agents. However, water, because of its hypotonicity, creates a flow into the tissue from the surface to the deep structures of the cornea. That makes it possible, in practice, for the corrosive agent to penetrate the anterior chamber more easily and more deeply. (13)





## EYE WASH

► **500 ML FOR 1 EYE TO BE USED WITHIN THE FIRST MINUTE**

# DIPHOTERINE®

> **Particular case of the SIEW** (Sterilised Individual Eyewash): Decontamination with a SIEW, containing 50 ml of Diphoterine®, requires washing within the first 10 seconds. In cases where washing has not begun within the first 10 seconds, it must be supplemented with a 500 ml bottle or a portable eyewash.

> **Contact lenses:** wearing contact lenses at work stations without protection and with exposure to chemical risk is generally discouraged. It is preferable to wear special protective prescription glasses. Safety goggles or a facial mask, to be placed over corrective lenses may also be used. Prescription glasses worn alone are not sufficient. In the case where contact lenses are worn, it is necessary to remove them as rapidly as possible in order to avoid any overconcentration of the chemical or deterioration of the contact lens, which will hinder the effectiveness of washing within the first seconds ■

### IN THE EVENT OF A CUTANEOUS SPLASH within the first minute:

- > **Use a Micro DAP**, a portable self-contained handspray (100 ml) or **Mini DAP** (200 ml), for a cutaneous projection on a respective area equivalent to a hand or an arm.
- > For a more extended chemical splash on the body use **a 5 litre DAP**.

### IN THE EVENT OF CHEMICAL CONTACT with oral mucous membranes within the first minute:

- > Possibility of washing with Diphoterine® and then spitting it out.

## 2.4 – MANAGEMENT OF A CHEMICAL SPLASH WASHED WITH DIPHOTERINE®

### 2.4.1 – Medical findings

Three types of cases are possible during the examination:

#### 1<sup>st</sup> case: absence of lesions

This happens frequently, because the Diphoterine® protocol has been applied correctly. Usually, no damage is observed and no secondary treatment is necessary. Consequently, there is generally no lost work time.

#### 2<sup>nd</sup> case: observation of a benign lesion

(for eyes: grade I and II of the Roper-Hall classification).

Benign occurrences observed in different situations concern most often the eyes than the skin. They are possibly delayed 24 or 48 h. It is a matter of ordinary signs of inflammation (simple ocular redness and slight sensation of pain). They require the application of a therapeutic protocol, generally anti-inflammatory and/ or anti- infection, by a specialist. It has been proven, notably concerning the eyes (12), that effective management of inflammatory symptoms is indispensable to the favourable development of the healing process.

There are different possible causes of these benign lesions. They can be due to:

- the nature of the chemical agent
  - product in solid form, responsible for mechanical erosion of the cornea with inflammation,
  - sensitising character (for example, chromium solution),
  - chemical splash under pressure





WALL-MOUNTED EYEWASH



► **FIXED EQUIPMENT FOR WASHING BEGUN WITHIN THE FIRST MINUTE AFTER THE ACCIDENT.**

## 2 DIPHOTERINE®

### 2.4.1 – Medical findings

- not respecting the initial washing protocol
    - delayed washing,
    - insufficient washing,
    - initial washing with water (almost non existent osmotic pressure. In these cases, the penetration of the corrosive agent towards the interior of the tissue is facilitated leading to deeper, more serious lesions),
    - Use of Diphoterine® as an eyebath, without the mechanical effect.
  - possible side-effects concerning an eventual prescribed medical treatment (for example reaction to certain components of topical ocular pharmaceutical solutions).
- Both acquired fundamental knowledge and a very strict vigilance system established a number of years ago, have eliminated all possibilities of negative interference of Diphoterine® used before medical treatment.

**3<sup>rd</sup> case: Serious lesions** (Ocular: grade III or IV of the Roper-Hall classification)

They are generally due to delayed washing observed after accidents in the home or, more rarely, at the time of criminal attacks where chemicals are used. According to the severity of the burn and its development, a complementary treatment (more or less complex and long) is essential. These cases require a very specialised and complex approach in a hospital setting.

### Clinical examination : Signs of the severity of an ocular burn (17)

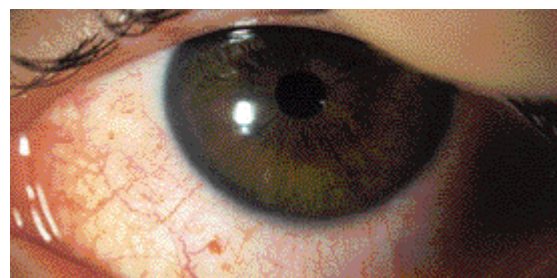
**Conjunctival hyperhemia** : diffused ocular redness by simple vasodilation of the conjunctive veins is not serious, sign of a simple conjunctival irritation.



**Conjunctival limbal ischaemia** (whitish zone): is due to the interruption of blood circulation at the level of the conjunctivo-limbal vessels. The extent of this ischaemia is the principal sign of the severity of the burn.

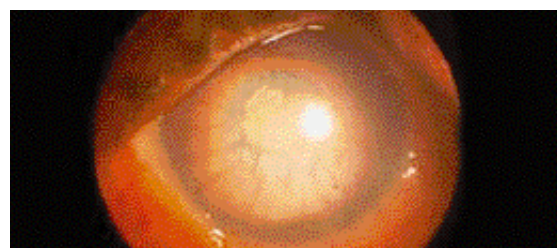
**Ischaemia greater than one-half of the limbic circumference is a factor in a poor prognosis.**

This ischaemia is often associated with chemosis (conjunctival oedema which is an elevated ring, often hemorrhagic (red spots).



**The corneal oedema** will be at the origin of a decrease in transparency, and the iris can just be made out or not seen at all (porcelain cornea). The result is then a decrease in visual acuity.

**An ulcer of the cornea** which is **complete** (affecting all of the corneal surface) and **deep** (affecting the epithelium and the corneal stroma) is a sign of severity. Paradoxically, in these cases, visual acuity can be preserved.



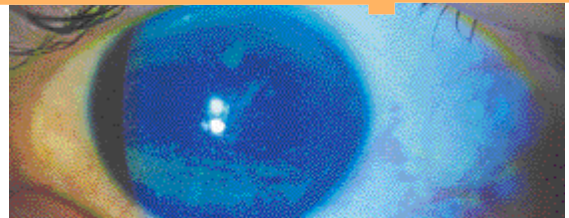


► 100 ML FOR ONE HAND OR FACE  
WITHIN THE FIRST MINUTE

## DIPHOTERINE®

### Clinical Exam : Signs of seriousness of an ocular chemical burn (17) continued...

In **minor corneal injuries**, such as **superficial punctual keratitis**, visual acuity is often decreased.



#### Associated lesions

- Burns on the eyelids: 1<sup>st</sup>, 2<sup>nd</sup> or 3<sup>rd</sup> degree
- Burns on the face or other parts of the body, which can have implications for patient survival

### 2.4.2 – Patient management in the company medical department

Washing with Diphoterine®, immediately carried out according to PREVOR's recommendations and using the entire contents of the container, prevents the burn from occurring or considerably decreases its severity.

#### > IN THE EVENT OF AN OCULAR SPLASH

Make sure that Diphoterine® washing has begun:

- with a SIEW (50 ml) within the first 10 seconds following the splash
- or with an Eyewash (500 ml) within the first minute

If not, for a contact time with the chemical substance greater than 1 minute, the chemical burn can already develop. Resume the initial washing performed with 500ml of Diphoterine® and follow it by a second washing, ideally for 5 minutes. A chemical burn is a biological invasion followed by an inflammatory reaction of the ocular tissues. Diphoterine® acts to stop this aggression. Then use a container of AfterwashII®, which is isotonic with human tears, to facilitate a more rapid return to a physiological state.

#### > IN THE EVENT OF A CUTANEOUS SPLASH

Make sure that Diphoterine® washing has begun within the first minute.

If not, for a contact time greater than 1 minute, resume washing with Diphoterine® for 3 to 5 times the duration of contact.

Then, in all cases, the patient should be referred to a specialist who will decide more precisely the action to be taken based on the lesions observed ■



**MINI  
DAP**



► **200ML FOR ONE FOREARM  
WITHIN THE FIRST MINUTE**

**2**

## **DIPHOTERINE®**

### **2.4.3 – Treatment by a specialist or at the hospital**

#### **OCULAR CHEMICAL BURN CLASSIFICATION (ROPER-HALL), prognosis and therapeutic protocol**

*according to a comparative clinical study (15) Diphoterine® versus normal saline solution*

Grade	Initial clinical exam	Prognosis	Therapeutic protocol after washing with 500 ml
<b>1</b>	Epithelial ulcer, no limbal ischaemia	Favourable	Verification of the anti-tetanus vaccination, rifamicyne 6 times/day, 2% ascorbic acid 6 times/day, tropicamide 6 times/day
<b>2</b>	Corneal oedema Ischaemia < 1/3 of the limbal circumference		
<b>3</b>	Complete corneal ulcer > 1/3 and Ischaemia > 1/2 of the limbal circumference	Poor	Verification of the anti-tetanus vaccination, rifamicyne 6 times/day, 2% ascorbic acid 6 times/day, dexamethasone combined with neomycine 6 times/day for 7 days, 1% atropine 3 times/day, 1 g ascorbic acid orally 3 times/day and installation of symblepharon rings. The treatment is maintained until complete reepithelialization of the cornea.
<b>4</b>	Opaque cornea with non visible iris Ischaemia > 1/2 of the limbal circumference		

A recently published case of an ocular grade IV burn, showed the advantages of using Diphoterine® under these conditions (15). The patient was treated approximately one hour after the chemical assault and an ocular washing with one litre of Diphoterine® was carried out. The treatment described in the above table was used for this patient.

The emergency number of PREVOR (+33 1 30 34 76 76) is placed at your disposal during business hours (time zone, France, GMT +1) for further information ■

### **2.5 – Formulation, innocuousness and classification of Diphoterine®**

#### **- Composition and properties of Diphoterine®**

- Aqueous saline solution containing Diphoterine®, does not contain phosphates
- Limpid and colourless liquid
- pH ranging between 7.2 and 7.7
- Density : 1.034
- Osmotic pressure : 820 mosmoles/kg
- Sterile solution (by autoclave)





► 5L TO WASH AN ENTIRE BODY  
WITHIN THE FIRST MINUTE.

## DIPHOTERINE®

### - Toxicological data concerning Diphoterine®

The tests of innocuousness carried out on Diphoterine® are summarised below:

Test	Results	References
Ocular irritation	Non irritant	Test n°133/4, on rabbits, Safeparm Laboratories Limited, UK, 1987
<i>In vitro</i> Evaluation of the eye irritation potential of a medical device	No cytotoxic or irritant potential to the eye after a short (10 minutes) or prolonged (24 hours) time of contact	Test n°REL/032/05/IRRO/ELB, on human fibroblast cultures, test Integra, Italy, 2005
Cutaneous irritation	Non irritant	Test n°2005-024, <i>in vitro</i> , Dermal Irritection® test method, Integra, Italy, 2005
Ocular irritation of a residue of a washing of an acid with Diphoterine®	Non irritant	Test n°6463 TAL, on rabbits, hydrochloric acid, CIT (International Centre of Toxicology), France, 1990
Ocular irritation of a residue of washing a base with Diphoterine®	Non irritant	Test n°6462 TAL, on rabbits, sodium hydroxide, CIT (International Centre of Toxicology), France, 1990
Oral toxicity	Oral LD <sub>50</sub> > 2000 mg/kg ; non toxic, no death, normal evolution of weight, no abnormality at necropsy	Test n°6564 TAR, on rats, CIT (International Centre of Toxicology), France, 1990
Acute dermal Toxicity	Acute dermal LD <sub>50</sub> > 2000 mg/kg; non toxic, no death, no sign of systemic toxicity or dermal irritation, normal evolution of weight, no abnormality at necropsy	Test n°133/9, on rats, Safeparm Laboratories Limited, UK, 1988
Sensitisation	Non sensitising	Test n°20030418ST, Magnusson and Kligman method, on Guinea pigs, OECD 406, CERB, France, 2003 (15)
Mutagenesis	Non mutagenic ; negative Ames test	Test n°29023 MMT, Bacterial reverse mutation Test on <i>Salmonella typhimurium</i> TA 1535, TA 1537, TA98, TA 100et TA 102, <i>Escherichia Coli</i> WP2 uvrA, CIT (International Centre of Toxicology), France, 2005
Cytotoxicity	Non cytotoxic	Test n°REL/003/06/IRRC/ELB, ISO 10993-5 standard, Integra, Italy, 2006
Anti-inflammatory potential	Non anti-inflammatory ; no cytotoxic or irritant effect observed on a 3D human epidermidis model	Test n°REL/011/06/FUNZ/ELB, MTT <i>in vitro</i> tests + pro-irritation potential IL-1α, Integra, Italy, 2006
Local tolerance on damaged skin/healthy skin (non-occluded and semi-occluded – 24 H)	No irritant or toxic effects	Test n°20060537TL, in the rabbit, CERB Laboratory, France, 2007
Local skin tolerance (occlusive test – 48 H on healthy volunteers)	Non irritant	Test n°1.01-48H, in humans, IDEA Laboratory, France, 2007







2

## DIPHOTERINE®

**NO SIDE-EFFECTS HAVE BEEN OBSERVED SINCE DIPHOTERINE® HAS BEEN PUT ON THE MARKET.**

**THE USE OF DIPHOTERINE® DOES NOT PRESENT ANY CONTRAINDICATIONS.**

### > PRECAUTIONS FOR USE

To avoid any microbial contamination, keep containers closed. Opened containers in eyewash stations should only be kept for six months. Do not use after the expiration date written on the containers.

### > ADVERSE EFFECTS

Chemical burns damage living tissues. Diphoterine®'s hypertonicity prevents the penetration of the tissue (13) and also extracts the chemical. For 1 minute of contact with the chemical, washing with 500ml of Diphoterine® prevents or minimises the appearance of the burn. If the contact time is greater than 1 minute, it is possible that a chemical burn will develop. The osmolarity of a healthy cornea is 420 milliosmoles/L. The osmolarity of a cornea attacked by a corrosive chemical can reach 2000 milliosmoles/L (not only because of the ionisation of the chemical substance, but also because of the liberation of electrolytes at the time of the lysis of the cells).

It is to minimise the osmotic shock that the use of a hyperosmolar washing solution is essential and demonstrates very beneficial effects in comparison to water.

Once the corrosive chemical substance is eliminated, the residual osmotic pressure of the cornea is generally approximately equal to 800 milliosmoles/L. To favourise the most gentle return to a physiological state, it may be useful and comfortable to use secondarily, as a complement to Diphoterine®, a special solution named "Afterwash II"® which is isotonic to tears. This solution is more adapted to this situation than both saline solution alone, which is hypotonic to tears, and water, whose osmolarity is almost inexistant, creating a second osmolar traumatism on already potentially damaged tissue.

### > WHEN SHOULD DIPHOTERINE® NOT BE USED?

Diphoterine®'s effectiveness is limited on hydrofluoric acid splashes because of the double corrosive and toxic mechanisms of this acid. Hexafluorine® has been specifically developed to address these two requirements.

Do not use in the event of splashes of white phosphorus. In the event of these types of splashes, it is better to use first-aid thermal burn treatment (a water-based gel for example) on the skin.

Diphoterine® is currently being tested for the treatment of chemical burns due to ingestion but has not yet been validated. Studies are currently in progress. However, it has already been tested and classified as non-toxic by oral route.

### > CLASSIFICATION OF DIPHOTERINE®

- Washing solution,
- Medical device,
- Class IIa, sterile,
- CE 0459, initial CE certificate obtained: September 1996, renewed January 31, 2007 after audit ■





# 3

## HEXAFLUORINE®

### 3.1 – HEXAFLUORINE®'S MECHANISM OF ACTION

Hexafluorine® is a specific washing solution for ocular and cutaneous hydrofluoric acid (HF) splashes (Figure 3) and fluorides in an acidic medium (e.g.: boron trifluoride). Hexafluorine® is a washing solution with hypertonic and chelating properties.

It thus has two mechanisms of action:

- the mechanical properties of water washing
- additional chemically active and chelating properties which accelerate and optimise the decontamination process
  - Hexafluorine®'s hypertonicity prevents the chemical from penetrating (10) the tissue and creates an inverse flow to pull the chemical to the tissue surface
  - Its neutralising and chelating properties enable it to act both on the corrosive ( $H^+$ ) and toxic ( $F^-$ ) components which are responsible for the particular severity of burns due to this acid ■

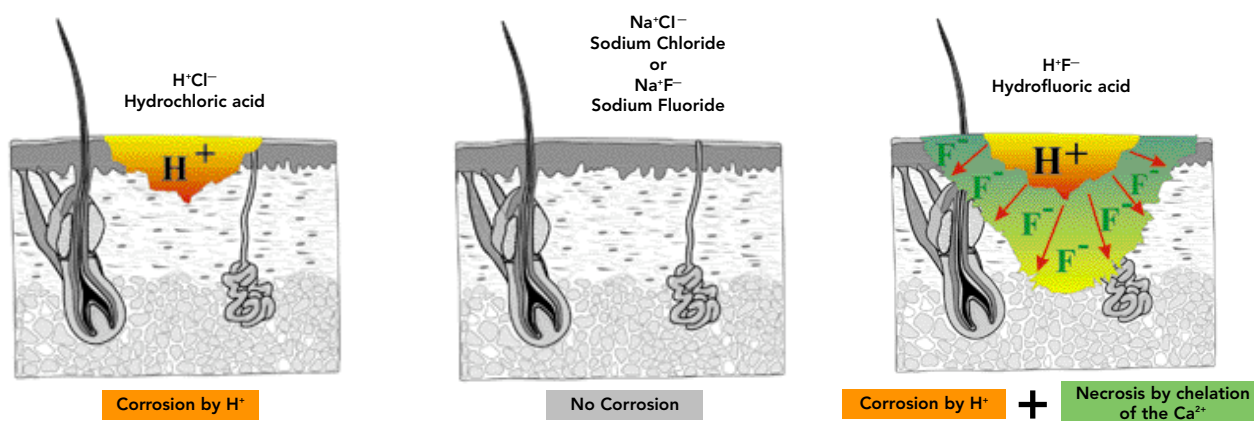
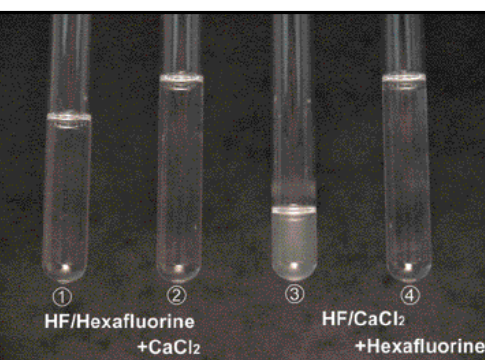


Figure 3: Hydrofluoric acid mechanism

The photographs in figure 4 highlight Hexafluorine®'s action *in vitro* on fluoride ions ( $F^-$ ). The chelation of calcium ions by fluoride ions, as much intracellullary at the point of contact as in the circulating blood, explains their toxic effect. Even a limited surface of diffusion can lead to the risk of hypocalcemia with potentially fatal cardiac disorders.



Hexafluorine® by capturing the  $F^-$  ion, free or precipitated, hinders this toxic mechanism.

Figure 4: Highlighting of Hexafluorine®'s action on free fluoride ions and on precipitate

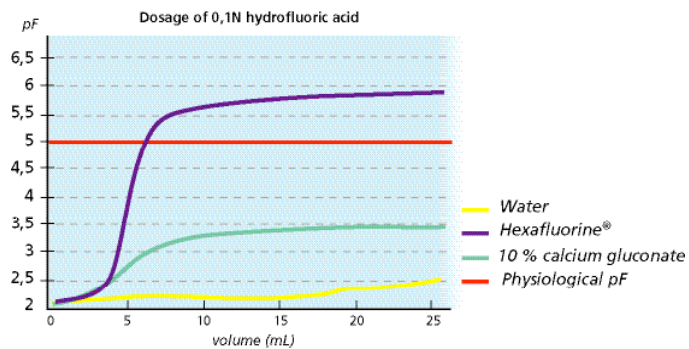
- ① and ②: 1ml of HF 1N and 7ml of Hexafluorine®: when 2ml of  $CaCl_2$  0.01N is added (test tube 2), **no  $CaF_2$  precipitated forms.**
- ③ and ④: 1ml of HF 1N and 2ml of  $CaCl_2$  0.01N (a precipitate of  $CaF_2$  forms). Tube 4 : 7ml of Hexafluorine® added: **Hexafluorine® captures the precipitated fluoride and the fluoride ions:** the solution becomes limpid again (photograph taken at + 1 hour).

## 3.2 - WASHING WITH HEXAFLUORINE®: ADVANTAGES COMPARED TO WATER

### 3.2.1 - *In vitro* chemical reactivity

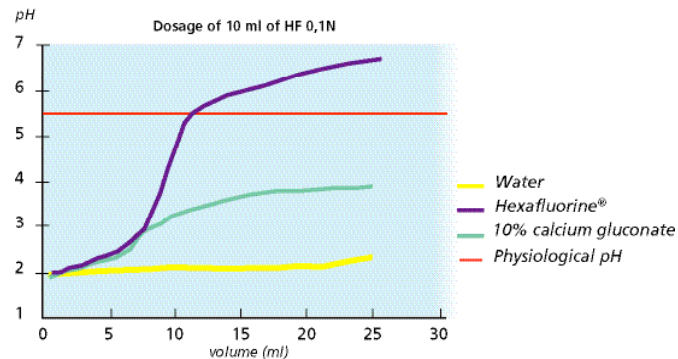
- The pF (fluoride ion potential) indicates the measure of  $F^-$  ions like the pH indicates the measure of  $H^+$  ions. The greater the pF, the lesser the quantity of free  $F^-$  ions is large. For a pH value greater than 5, the product is not considered to be dangerous (physiological pF) ■

Figure 5: Efficacy of Hexafluorine® on free radical fluoride ions compared to water and a calcium gluconate solution



- As with water, the rapid use of Hexafluorine® is aimed at avoiding the chemical burn due to HF. The more rapidly that Hexafluorine® is used, the shorter the contact with the hydrofluoric acid will be. Thus the risk of a chemical burn developing will be decreased significantly ■

Figure 6: Efficacy of Hexafluorine® on  $H^+$  corrosive ions compared to water and a calcium gluconate solution



### 3.2.2 - Dynamic and physical highlighting of washing effectiveness.

- The OCT-HR technique (Optical Coherence Tomography - High Resolution) allows, on slices of the cornea, to visualize the penetration of the irritating or corrosive chemical substance into the cornea's internal layers. A recent study (18) has shown the total penetration of 2.5% hydrofluoric acid into the cornea in 240 seconds. This study has shown that Hexafluorine® rapidly stops the penetration of the hydrofluoric acid with a clear cornea after 75 minutes of observation.

Comparatively, the corneas washed with water or 1% calcium gluconate are opaque, a phenomena characteristic of a severe HF burn ■

HF burn with no washing

HF burn washed with water

HF burn washed with 1 % calcium gluconate

HF burn washed with Hexafluorine®

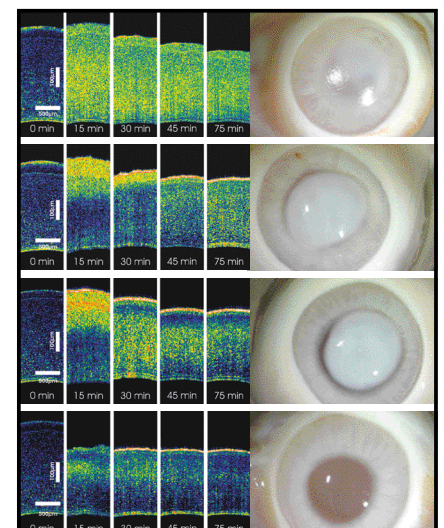


Figure 7: Highlighting of the influence of different washing solutions on the penetration of HF in rabbit eyes ex vivo, 20 seconds of exposure, 25µl of 2.5 % HF (grade 2 burn), 15 minutes of washing



## EYE WASH



► 500 ML FOR 1 EYE  
WASHING BEGUN WITHIN  
THE FIRST MINUTE

## HEXAFLUORINE®

The use of Hexafluorine® permits a rapid neutralisation of the corrosive and toxic potential of HF with a low volume of washing, whereas a progressive addition of water only dilutes the hydrofluoric acid solution. The residual mixture of HF and water remains very aggressive.

Two *in vivo* experiments were performed (21):

### • DEVELOPMENT OF THE BURN

> The first study was carried out on a cutaneous burn due to 70% HF lasting 20 seconds, in order to observe the comparative histological effects between washing with water, washing with water followed by the topical application of a 2,5% calcium gluconate gel, and washing with Hexafluorine®. The intensity of the reaction was established according to a modified Draize scale.

The main observations of the burn grade after washing were summarised as shown below:

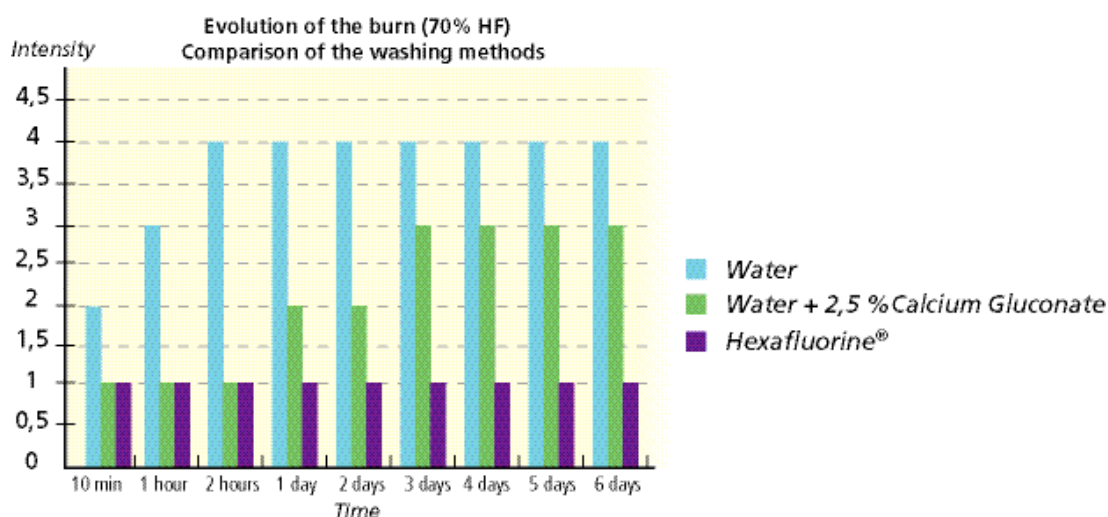


Figure 8: Comparison of the efficacy of washing methods following a experimental cutaneous exposure during 10 minutes to 25µl of 70% HF (grade 2 burn).

Washing with water, which does not trap hydrofluoric acid, is not sufficient to stop the evolution of the burn, which quickly becomes a serious burn.

The use of calcium gluconate blocks the appearance of the burn, at least during the first 24 hours, but a single application is not sufficient to eliminate all fluoride ions. When the treatment is stopped, the burn re-appears, because the residual rate of free fluorides is still above the toxicity limit.

The immediate use of a powerful chelating agent like Hexafluorine® suppresses the action of hydrofluoric acid and does not let any possibility for F<sup>-</sup> ions to get linked to the calcium into the tissues. The observation of the animals during 6 days does not show any after-effects after a single washing with Hexafluorine® whereas water requires a secondary treatment and calcium gluconate requires multiple applications or injections ■

### • DEVELOPMENT OF THE CALCEMIA

- In a second *in vivo* study, the evolution of the development of the calcemia (Figure 7) during 5 days in rats contaminated by 70% hydrofluoric acid ■

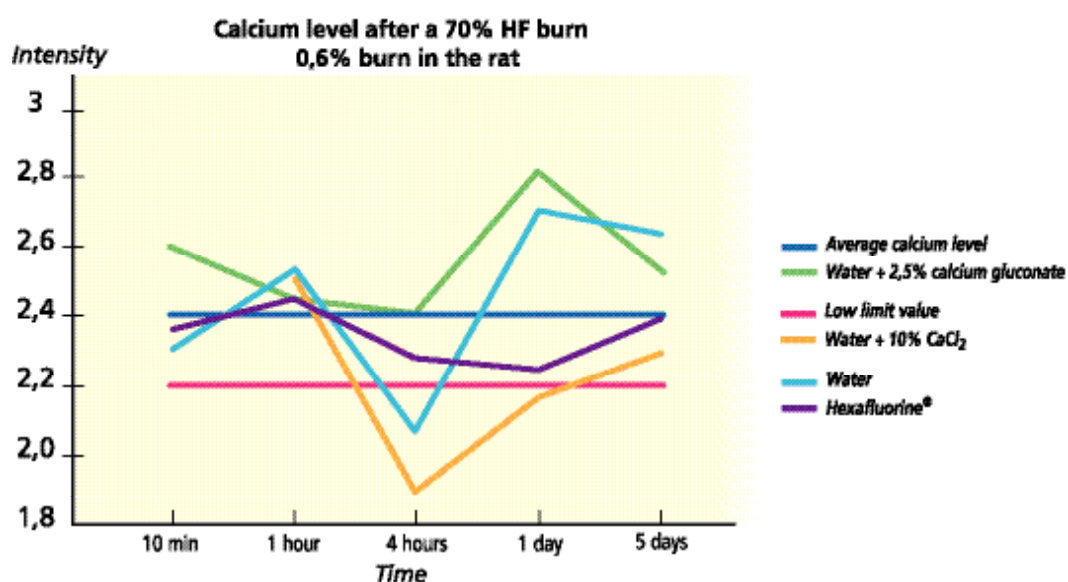


Figure 9: Comparative evolution of the calcium level after decontamination of a cutaneous experimental burn due to 70 % HF

- The analysis of the data shows that washing with water, water + CaCl<sub>2</sub> or water and calcium gluconate have similar results. Statistically, the measures of calcemia carried out between 10 minutes and 1 hour are the same. Significant hypocalcemia can be seen after 4h (for washing with water and washing with water + 10 % CaCl<sub>2</sub>) and an improvement after 24 h followed by stabilisation. **The results clearly show that the calcemia remains normal and stable after washing with Hexafluorine®** ■

### • CASE STUDIES

32 cases of ocular or cutaneous hydrofluoric acid splashes which were washed with Hexafluorine® have been published in the scientific literature. Among them, 5 cases could have presented a lethal risk according to the classification proposed by Dunser (25), but for all the cases the results were the following:

- After each washing, the patient very rapidly noted pain relief, facilitating the decontamination process.
- **No after-effects were reported** in any of the cases. The loss of work was minimal, one day on average (19, 20, 21) ■





**DAP**



► **5L TO WASH AN ENTIRE BODY  
WITHIN THE FIRST MINUTE.**

## HEXAFLUORINE®

### 5 case studies of emergency decontamination with Hexafluorine®(1)

Number of cases	Splashed by	Affected body surface	Type of washing	Consequences/Results
1	HF/HCl bath	Total immersion	Hexafluorine® on the body,	Slight burns on the abdomen and the back
			Ocular washing with water	Serious burn on the left eye
1	70% HF vapour	Right cheek	Hexafluorine®	Slight painless erythema . Application the next day with calcium gluconate gel, no lost work time
1	38% HF	One eye	Hexafluorine®	No burns, no lost work time
2	5% HF	Body	Hexafluorine®	No burns, no lost work time

### SERIES OF 16 CASES AT OUTOKUMPU (AVESTA, various sites, Sweden) (23)

#### Decontamination with Hexafluorine®

Number of Cases	Splashed with	Affected body surface	Duration of contact	Work loss
2	70% HF	Left forearm– oral cavity	< 1 min	0 - 1
1	HF (concentration unknown)	One eye	< 1 min	0
2	HF/HNO <sub>3</sub> pH=1	One eye	< 1 min	0 - 0
1	HF/HNO <sub>3</sub> pH=1*	One eye	3 - 5 min	3
1	HF/HNO <sub>3</sub> pH=1	Two eyes	< 1 min	0
1	HF/HNO <sub>3</sub> pH=1	One thigh	< 1 min	0
2	HF/HNO <sub>3</sub> pH=1	Two thighs	1h - 1h30	2 - 2
1	HF/HNO <sub>3</sub> pH=1*	Face	3 - 5 min	3
2	HF/HNO <sub>3</sub> pH=1	Face + oral cavity – Forehead	< 1 min	1 - 1
3	HF/HNO <sub>3</sub> pH=1	Fore arm– arm + hand – Two elbows	< 1 min	0 – 0 - 1
1	HF/HNO <sub>3</sub> pH=1	Wrists	2 h	0
<b>RESULTS</b>	<b>Immediate analgesic effect, no sequelae. In 75% of cases including two splashes with 70% HF, no additional care was required and the average lost work time was less than 1 day (<math>\sigma = 1.1</math>)</b>			

HF/HNO<sub>3</sub> mixture: HF 6% and HNO<sub>3</sub> 15%

\*preparation including sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) with an unknown concentration





**EYE  
WASH**



**DAP**



### 3 HEXAFLUORINE®

#### SERIES OF 11 CASES AT THE MANNESMANN PLANT (Remscheid, Germany)

Splash	40% HF	6% HF /15% HNO <sub>3</sub>	40%HF	6% HF / HNO <sub>3</sub> 15%
Number of cases	1	1	5	5
% Affected area	1 eye*	1 eye	0.2 – 1 – 4.5 – 4.5 – 16.5*	0.2 – 2.25 – 4 – 4.5 – 10.5
First washing (on the site of the accident)	Hexafluorine®	Hexafluorine®	Hexafluorine®	Hexafluorine®
Second washing (at the infirmary)	Hexafluorine®	Hexafluorine®	Hexafluorine®	Hexafluorine®
<b>RESULTS</b> No sequelae, no further care required no lost work time				

\* ocular and cutaneous splash with 40% HF

#### 3.3 - WHEN AND HOW SHOULD HEXAFLUORINE® BE USED?

- The use of Hexafluorine® is appropriate in the event of emergency decontamination of splashes with hydrofluoric acid and fluorides in an acid solution.

Performed within the first minute after the splash and using the entire amount of the appropriate product container, the purpose of external washing with Hexafluorine® is to prevent or minimise the appearance of lesions and thus the risks of sequelae ■

#### WASHING PROTOCOL WITH HEXAFLUORINE®

**Wash first as rapidly as possible within  
the first minute for optimal efficacy  
and  
remove clothing and/or contact lenses.  
Continue washing, being sure to use the entire contents  
of the Hexafluorine® container.**

**Consult a specialist**

#### GENERAL INSTRUCTIONS

**Never delay washing  
For optimal effectiveness use an active solution  
such as Hexafluorine®  
available at the work site  
If Hexafluorine® is not available, use water  
then apply locally a specific antidote such as calcium gluconate**



## FOR OCULAR WASHING:

- > Less than one minute of contact with the chemical requires 3 minutes of washing, in other words a 500 ml bottle or a portable eyewash pouch.

There is a minimal time period of about 10 seconds before the aggressive chemical begins to penetrate the cornea. For that reason, water can sometimes be effective, in particular with weak corrosive agents. However water, because of its hypotonicity, creates a flux of the chemical from the exterior towards the interior of the cornea. That makes it possible for the corrosive substance to penetrate the anterior chamber more rapidly and deeply (13).

> **Contact lenses:** wearing contact lenses at work stations without protection and with exposure to chemical risk is generally discouraged. It is preferable to wear special protective prescription glasses. Safety goggles or a facial mask, to be placed over corrective lenses may also be used. Prescription glasses worn alone are not sufficient. In the case where contact lenses are worn, it is necessary to remove them as rapidly as possible in order to avoid any overconcentration of the chemical or deterioration of the contact lenses, which will hinder the effectiveness of washing within the first seconds ■

## IN THE EVENT OF A CUTANEOUS SPLASH

- > For a chemical splash on the body and a contact time with the chemical less than one minute, use a 5 litre DAP (Autonomous Portable Shower)

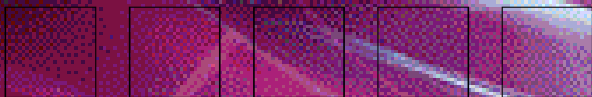
## IN THE EVENT OF CHEMICAL CONTACT WITH ORAL MUCOUS MEMBRANES WITHIN THE FIRST MINUTE:

- > Possibility of washing with Hexafluorine® and then spitting it out.

## 3.4 - MANAGEMENT OF A CHEMICAL SPLASH WASHED WITH HEXAFLUORINE® AT THE COMPANY MEDICAL DEPARTMENT

### 3.4.1 – Patient management in the company medical department

Washing with Hexafluorine® performed according to PREVOR's recommendations, immediately and using the entire contents of the appropriate container, prevents the appearance of burns or considerably decreases their severity .

**> IN THE EVENT OF AN OCULAR SPLASH**

Ensure that the Hexafluorine® washing has begun within the first minute with a wall-mounted or portable eyewash (500 ml).

If not, for a contact time greater than 1 minute, resume washing with Hexafluorine® and if needed, continue the washing for 3 to 5 times the duration of contact time. HF causes an acid burn from the  $H^+$  ion and tissue damage and potential systemic toxicity from the  $F^-$  ion, leading to frequently observed severe eye injuries. Hexafluorine® stops both of these actions. Then use Afterwash II®, isotonic with human tears, to facilitate a more rapid return to a physiological state.

**> IN THE EVENT OF A CUTANEOUS SPLASH**

Ensure that washing with Hexafluorine® begun within the first minute.

If not, for a contact time greater than 1 minute, continue washing with Hexafluorine® and if needed, continue washing for 3 to 5 times the duration of contact time to stop the action of the corrosive chemical. All the more reason that in the case of delayed washing, the systemic risk requires management of the patient by a doctor.

- Effects of hydrofluoric acid (23):

Concentration > 50%	immediate pain and necrosis
Concentration 20% - 50%	burn delayed from 1 to 8 hours
Concentration < 20%	pain and necrosis delayed by up to 24h

- Lethal systemic risk with hydrofluoric acid burns (24):

Type of burn	Affected surface	Concentration HF
Burn by contact	1 %	anhydrous
	5 %	> 70 %
	7 %	50 - 70 %
	10 %	20 - 50 %
	20 %	< 20 %
Ingestion of HF		> 5 %
Inhalation of HF		

## 3.4.2 – Treatment by a specialist or at the hospital

### > OCULAR BURNS

Every hydrofluoric acid ocular burn must be initially and subsequently handled medically because of the frequent disparity between initial appearance and the severity of the sequelae. The treatment of ocular HF burns is similar to the treatment of other chemical burns; specific antidotes can be used according to the company medical protocol and during pre-hospital and hospital management of the injured person ■

### > CUTANEOUS BURNS

#### 1) Medical Treatment

Generally, after emergency decontamination, protocols recommend the use of specific antidotes: topical, sub-cutaneous, intravenous (Beir block technique), or intra-arterial (for finger and hand burns) such as calcium gluconate or Zéphiran® salts (20). Analgesic treatment may also be prescribed. Medical surveillance of cardiovascular functions may be justified due to the systemic diffusion of HF in relation to the concentration and the total affected body surface area ■

#### 2) Additional examinations

Blood tests to be ordered especially if the burn involves more than 1% of the total body surface area (TBSA):

- calcemia
- kalemia
- magnesemia
- phosphoremia

## Case study of a hydrofluoric acid burn (7)



A 45 year old worker, was splashed with a cutaneous 70% HF projection (face, neck, an arm and the abdomen, with a systemic effect which could be lethal, see table, paragraph 3.4), while he was checking a valve. Immediate washing was carried out with water at the accident site for 15 minutes, then with saline solution while being transported to the hospital. The patient received intravenous injections of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  as well as local applications of calcium gluconate gel.

► 1 YEAR OF LOST WORK TIME

### Case study of decontamination with Hexafluorine® (18)



A 40 year old worker, was splashed while decanting 40% HF. This was an ocular and cutaneous splash and corresponds to 16.5% of the body surface (eyes, face, neck, thorax, with a risk of lethal systemic effect, see table, paragraph 3.4). Washing was immediately carried out with Hexafluorine® on the eyes and the body at the site of the accident. The injured worker was washed a second time with Hexafluorine® at the company's infirmary by medical personnel. At the hospital, an absence of after-effects was noted, and there was no need for secondary care.

► **NO LOST WORK TIME**

## 3.5 – FORMULATION, INNOCUOUSNESS AND CLASSIFICATION OF HEXAFLUORINE®

### > FORMULATION AND PROPERTIES OF HEXAFLUORINE®

- Aqueous saline solution containing Hexafluorine®, does not contain phosphates
- Limpid and colourless liquid
- pH ranging between 7.2 and 7.7
- Density : 1.047
- Osmotic pressure : 1030 mosmoles/kg
- Sterile solution (by autoclave)

### > INNOCUOUSNESS OF HEXAFLUORINE®

Tests of innocuousness performed on Hexafluorine® are summarised below:

Test	Results	References
Ocular irritation	Non-irritating	Test n°133/8, on rabbits, Safepharm Laboratories Limited, UK, 1987
Cutaneous irritation	Non-irritating	Test n°133/7, on rabbits, Safepharm Laboratories Limited, UK, 1987
Sensibilisation	Classified non-allergenic	Test n°20040231STC, Magnusson and Klingman method on guinea pigs, CERB, France, 2004
Toxicity by oral route	Oral LD <sub>50</sub> (rat): > 2000 mg/kg; non-toxic, no deaths, normal weight gain, no post-mortem anomalies	Non-toxic (test n°990533ST on rats, CERB, France 2000)



## > PRECAUTIONS FOR USE

To avoid any microbial contamination, keep containers closed. Opened containers in eyewash stations should only be kept for six months. Do not use after the expiration date written on the containers.

## > ADVERSE EFFECTS

HF ocular burns can lead to significant injuries. Hexafluorine® because of its hypertonicity, stops the penetration and extracts the HF. For 1 minute of contact with hydrofluoric acid, washing with 500ml of Hexafluorine® prevents or minimises the chemical burn. If the duration of contact is more than 1 minute, the chemical burn will appear.

The osmolarity of a healthy cornea is 420 milliosmoles/L. The osmolarity of a cornea attacked by a corrosive chemical can reach 2000 milliosmoles/L (not only because of the ionisation of the chemical substance, but also because of the liberation of electrolytes at the time of the lysis of the cells).

It is to minimise the osmotic shock that the use of a hyperosmolar washing solution is essential and demonstrates very beneficial effects in comparison to water washing.

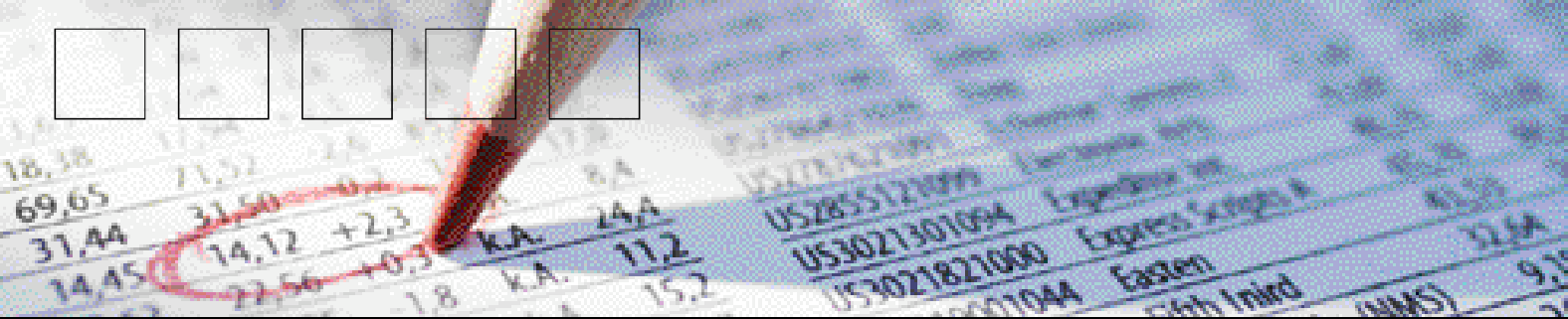
Once the corrosive chemical substance is eliminated, the residual osmotic pressure of the cornea is generally approximately equal to 800 milliosmoles/L. To encourage the most gentle return to a physiological state, it may be useful and comfortable to use secondarily, as a complement to Hexafluorine®, a special solution named "Afterwash II"® which is isotonic to tears. This solution is more adapted to this situation than both saline solution alone, which is hypotonic with tears, and water, whose osmolarity is almost inexistant, creating a second reverse osmolar traumatism on already potentially damaged tissue.

## > WHEN SHOULD HEXAFLUORINE® NOT BE USED?

Hexafluorine® is less effective on alkaline solutions. The use of Diphoterine® is much better adapted to such cases. Currently, there is no evaluation program for burns resulting from ingestion, but it has been tested and classified as non-toxic by ingestion.

## > CLASSIFICATION OF HEXAFLUORINE®

- Washing solution,
- Medical device
- Class IIa, sterile
- CE 0549, initial CE certificate September 30, 1996, renewed January 31, 2007 after audit



## 4

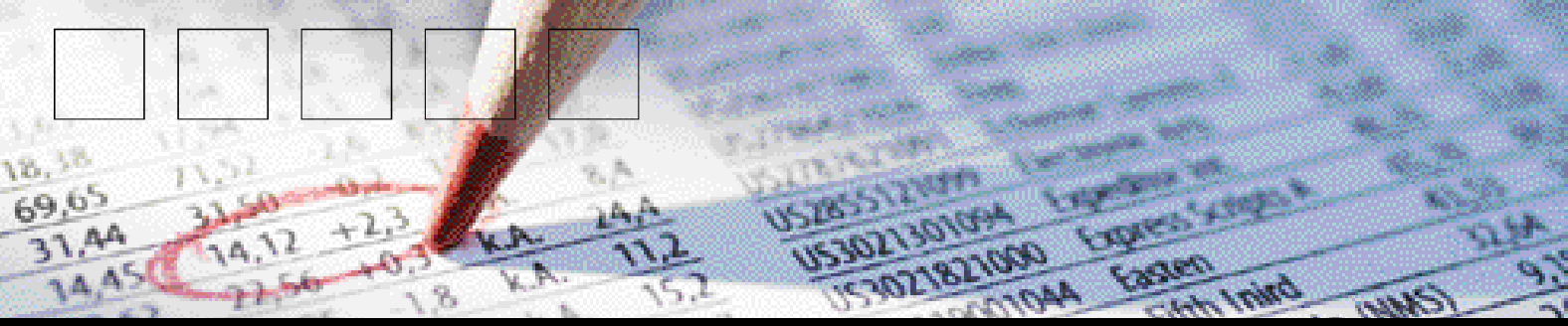
# CONCLUSION

## Improvement of the management of chemical splashes

**Diphoterine®** brings a general-purpose response to aggressive chemicals. It improves the management of ocular and cutaneous chemical splashes by pushing back the time of intervention in emergency situations to 1 minute after the splash for optimal effectiveness. When the intervention time is greater than 1 minute, the chemical burn will have already appeared. The delayed use of Diphoterine® will make it possible to stop the chemical's action on the tissues and to minimise the evolution of the burn, as well as associated pain and inflammation. By limiting the burn, Diphoterine® allows, under better conditions, the application of therapeutic protocols according to the severity of the burn.

**Hexafluorine®** improves the management of ocular and cutaneous splashes of hydrofluoric acid or fluorides in an acidic medium. Used within the first minute, its effectiveness is optimal. If the contact time is longer than one minute, in addition to Hexafluorine®, apply a treatment based on a chelating fluoride antidote such as calcium gluconate.

1. Mathieu L, Burgher F, Blomet J. Comparative evaluation of the active eye and skin chemical splash decontamination solutions Diphoterine® and Hexafluorine® with water and other rinsing solutions: Effects on burn severity and healing. *Journal of Chemical Health And Safety*, 2007, 14, N°4, 32-39
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# 6

## SUMMARY SHEETS

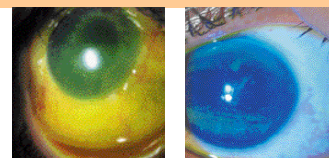
# DIPHOTERINE® IN USE

## I

### NATURE AND PROPERTIES

> **Diphoterine®** is a washing solution designed for ocular and cutaneous chemical splashes. Set up at the work station and used as first-aid, it allows the minimisation or avoidance of the development of chemical burns, stopping both the effect and the penetration of the irritant and/or corrosive by way of its amphoteric, chelating and hypertonic properties. Diphoterine®, dispensed in specially designed containers, permits and facilitates effective decontamination, reduces pain, the need for secondary care, sequelae and lost work time.

A clinical study carried out in a hospital setting has shown the advantages of even delayed washing with Diphoterine® for the management of ocular chemical burns, combined with a therapeutic protocol aimed at reducing inflammation and at preventing infection while encouraging healing. A published grade IV case likewise developed progressive reepithelialization in less than 21 days and complete and stable healing without surgery after 180 days ■



## 2

### HOW SHOULD THIS DEVICE BE USED?

#### > In the workplace

- Washing within the first minute and as the primary action with the entire Diphoterine® container.

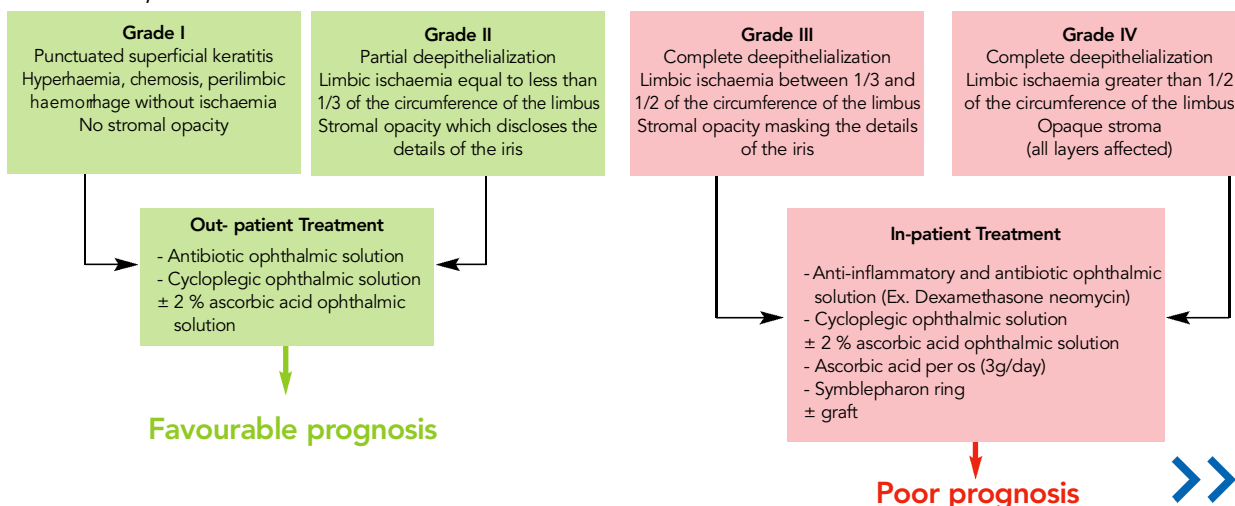
SIEW	Portable eyewash	Mural eyewash	Micro DAP	Mini DAP	DAP
					
50 ml within the first 10 seconds	500 ml within the first minute	500 ml within the first minute	100 ml within the first minute to wash one hand	200 ml within the first minute to wash one arm	5 Litres within the first minute to wash a body

#### > At the accident and emergency department

##### • For an ocular splash

- Wash again with 500ml of Diphoterine® followed by a secondary therapeutic protocol.

Based on Roper-Hall classification of ocular chemical burns: prognostic and therapeutic protocol from "Ophtalmologie en urgence" [Emergency Ophthalmology] by Dr Tuil, De Nicola, Mann, Miléa and Barale; Elsevier-Masson Editions 2007.





• **For a cutaneous splash**

- Wash with a quantity of Diphoterine® in proportion to the surface area exposed.
- In the case of delayed use, washing with Diphoterine® should be continued 3 to 5 times the contact time if necessary or by spraying in a constant stream to keep the area moist and to reduce pain.

## 3

## INNOCUOUSNESS

Test	Results	References
<i>In vitro</i> evaluation of the <b>ocular irritating potential</b> of a medical device (10 min or 24 hours)	Non-cytotoxic or irritating	Test n°REL/032/05/IRRO/ELB, Integra Laboratory test, Italy, 2005
<b>Cutaneous irritation</b>	Non-irritating	Test n°2005-024, <i>in vitro</i> , Dermal Irritation® test method, Integra Laboratory, Italy, 2005
<b>Local cutaneous tolerance</b> (occlusive test - 48 h on healthy volunteers)	Non-irritating	Test n°1.01-48h, in humans, IDEA, France, 2007
<b>Sensitization</b>	Non-allergenic	Test n°20030418ST, CERB, in the guinea pig, OECD 406, France, 2003
<b>Toxicity by oral route</b>	Non-toxic ; oral DL <sub>50</sub> > 2000 mg/kg	Test n°6564 TAR, in the rat, CIT Laboratory, France, 1990

> **Classification:** Sterile medical device, class IIa

> **Therapeutic indications:**

Washing of ocular and cutaneous chemical splashes (or oral mucous membranes, followed by spitting out).

> **Manufacture's name and address**



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## 4

## CONTRAINDICATIONS

There are no known negative interactions with the different families of medicines or devices and more specifically with ophthalmic solutions used in chemical burn protocols.

Do not use in cases of splashes due to white phosphorous. In these cases please use an emergency treatment specifically designed for thermal burns (such as a hydrogel).

Diphoterine® is currently being tested for the treatment of chemical digestive burns but has not yet been validated. However, it has already been tested and classed as non-toxic if swallowed.

Diphoterine® has a limited effect on hydrofluoric acid splashes due to the double corrosive and toxic mechanism of this acid. Washing with Hexafluorine® is better adapted to these two requirements.

> **Side effects**

**No side effects have been reported by our vigilance system.**

Washing with Diphoterine® may cause temporary ocular discomfort. The secondary use of the solution Afterwash II®, isotonic with tears, brings about a more rapid return to a physiological state.

> **Precautions for use**

To avoid any microbial contamination, keep containers closed.

Do not use after the expiry date which appears on the container.

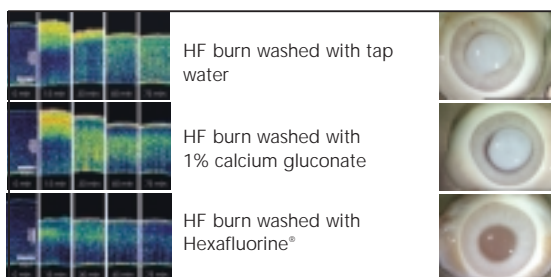
Products for single use only.

# HEXAFLUORINE® IN USE

## I

### NATURE AND PROPERTIES

> **Hexafluorine®** is a washing solution designed specifically for ocular and cutaneous chemical splashes due to hydrofluoric acid (HF) and due to fluorides in an acid medium. Set up at the workplace and used as first-aid, it allows the minimisation or avoidance of the burn's appearance, stopping the corrosive and toxic effects of solutions containing HF and by avoiding the penetration of the tissues by way of its chelating and hypertonic properties. Hexafluorine®, dispensed in specially designed containers, permits and facilitates effective decontamination, reduces pain, the need for secondary care, sequelae (after-effects) and lost work time ■



Opaque cornea = burn

Transparent cornea = no burn

Kinetics of decontamination of hydrofluoric acid detected by the Optical Coherence Tomography Technique

(Spöler & al. Analysis of hydrofluoric acid penetration and decontamination of the eye by means of time-resolved optical coherence tomography / Burns 2008 june; 34 (4): 549-555)

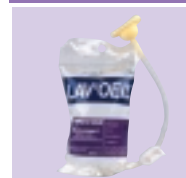
## 2

### HOW SHOULD THIS DEVICE BE USED?

#### > In the workplace

- Washing in the first minute and as the primary action with the entire container of Hexafluorine®.
- Specific antidotes, such as calcium gluconate may be used according to the protocol established by the doctor in charge. This is especially important in cases of delayed or insufficient washing, when the burn has already developed.

#### Portable eyewash



500 ml within the first minute

#### Mural eyewash



500 ml within the first minute

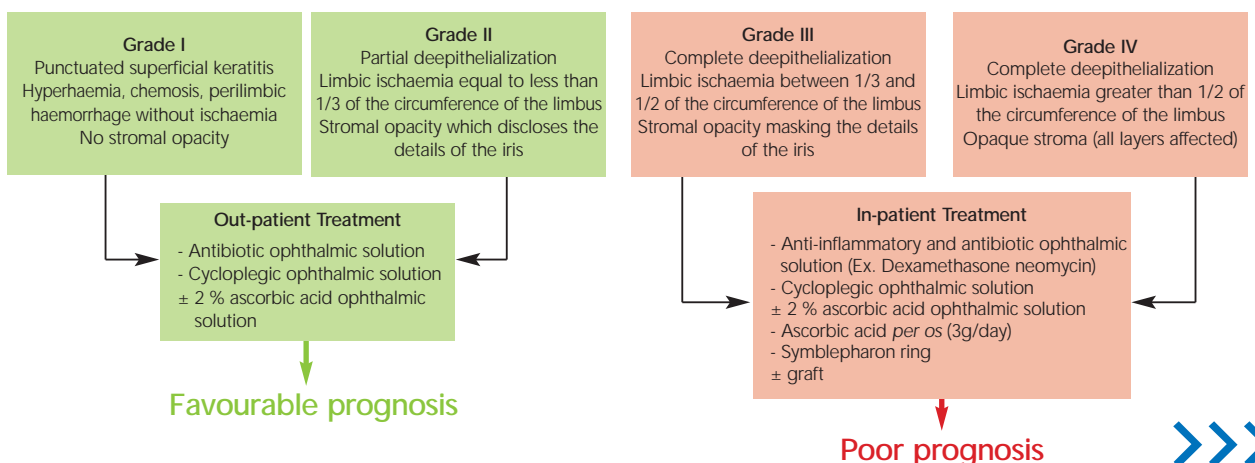
#### DAP



5 Litres within the first minute to wash an entire body

#### > At the accident and emergency department

- **For an ocular splash**, wash with 500 ml of Hexafluorine® followed by a secondary therapeutic protocol. Based on Roper-Hall classification of chemical ocular burns: prognostic and therapeutic protocol from « Ophtalmologie en Urgence [Emergency Ophthalmology] » Dr Tuil, De Nicola, Mann, Miléa et Barale; Elsevier-Masson Editions 2007.



## - For a cutaneous splash

The use of specific topical antidotes, such as calcium gluconate or Zephiran® salts, by subcutaneous injections, or intravenous (Beir Block technique), by intra-arterial injections (for fingers or the hand) is recommended in the scientific literature. This may be combined with a symptomatic analgesic treatment. Monitoring of cardiovascular functions may be justified by the systemic diffusion in relation to the cutaneous surface area affected and the concentration.

If the burn surpasses 1% of the surface of the body, complementary analyses should be requested: calcemia, kaliemia, serum magnesemia, phosphatemia.

> **Classification:** medical device, class IIa

## > Therapeutic indications

Washing of ocular and cutaneous splashes due to hydrofluoric acid and fluorides in an acidic medium.

## > Name and address of the manufacturer:



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## 3

## INNOCUOUSNESS

Test	Results	References
Ocular irritation	Non irritating	Test n°133/8, in the rabbit, Safepharm Laboratories Limited, UK, 1987
Cutaneous irritation	Non irritating	Test n°133/7, in the rabbit, Safepharm Laboratories Limited, UK, 1987
Sensitization	Non allergenic	Test n°20040231STC, Magnusson & Kligman method in the guinea pig, CERB, France, 2004
Toxicity by oral route	Non toxic ; oral LD <sub>50</sub> > 2000 mg/kg	Test n°990533ST, in the rat, CERB, France, 2000

## 4

## CONTRAINDICATIONS

There are no known negative interactions with the different families of medicines or devices and more specifically with ophthalmic solutions used in specific chemical burn protocols.

At this time there is no evaluation program for burns due to swallowing. However, Hexafluorine® has been classified as non-toxic by ingestion.

Hexafluorine® has a reduced effect on alkaline substances. Washing with Diphotérine® is much better adapted in this type of situation.

## > Side effects

**Our vigilance system has not highlighted any side effects.**

Hypertonic ocular washing with Hexafluorine® may leave a temporary sensation of ocular discomfort. The secondary use of the solution Afterwash II®, isotonic with tears, brings about a more rapid return to a physiological state.

## > Precautions for use

To avoid any microbial contamination, keep containers closed.

Do not use after the expiry date which appears on the containers.

Products for single use only.



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# VIGILANCE SYSTEM FEEDBACK

## MANAGEMENT OF A CHEMICAL BURN

Please complete this form and return it **either by email ([www.prevor.com](http://www.prevor.com)), or by fax (+33 130347670)**.  
The gathering of this information will allow us to enrich our data base concerning the management and the consequences of chemical burns.

### INFORMATION CONCERNING THE ACCIDENT VICTIM

Gender: ☐ F ☐ M

Age: .....years old

Job/Post: .....

### INFORMATION CONCERNING THE CHEMICAL SUBSTANCE

Name of the chemical: .....

Chemical class: ☐ acid ☐ base **pH of the solution** : ..... ☐ oxidiser ☐ reducing agent ☐ Solvent  
☐ other (specify): .....

Product concentration: ..... Composition (attach the MSDS to the file): .....

Temperature: ☐ cold ☐ hot (T°C = ..... ) Chemical splashed under pressure: ☐ (P = ..... )

Physical appearance: ☐ liquid ☐ solid ☐ gas

### ACCIDENT DETAILS

Date: ..... Time: ..... How? : ☐ work ☐ do-it-yourself ☐ in the home ☐ attack

Type of splash : ☐ ocular ☐ facial ☐ neck ☐ arm ☐ forearm ☐ hand ☐ thigh ☐ leg ☐ foot  
☐ anterior thorax ☐ anterior abdomen ☐ posterior thorax ☐ posterior abdomen  
☐ other (specify): .....

Quantity of substance: .....

Sub-cutaneous penetration: ☐ yes ☐ no

☐ by pression ☐ wound ☐ Pre-existing dermatosis

Ocular antecedents (specify): .....

### EMERGENCY WASHING IN THE WORKPLACE

Date : ..... Time : .....

Time lapsed between the splash and the beginning of the washing process: .....

Nature of the **primary** washing: ..... Nature of **secondary** washing: .....

Place: ☐ Company ☐ Infirmary ☐ Ambulance

Quantity / packaging: ..... Quantity / packaging: .....

Length of washing: ..... Length of washing: .....

Additional Information: .....

### PATIENT FOLLOW-UP BY A SPECIALIST OR AT THE HOSPITAL

Date: ..... Time: .....

**Initial clinical observation:** .....

**What was the medical protocol applied?** .....

Washing? ☐ YES ☐ NO

■ If yes: what was the nature of the washing? .....

Quantity/ type of container: .....

Length of the washing: .....

pH measurement? ☐ YES: Value before washing, pH =..... value after washing, pH =..... ☐ NO

Washing resumed? ☐ YES ☐ NO

■ If yes : type of washing:

Quantity: type of container: .....

Length of washing: .....

**Description of secondary treatment:** .....

.....

.....

### PATIENT FOLLOW-UP

■ **Short term** Observation date (day/month/year): .....

**Eye:** • visual acuity: Right eye: ..... Left eye: ..... Binocular: .....

• grade: ☐ absence of visible lesion ☐ I ☐ II ☐ III ☐ IV

• Total time needed for reepithelialization: .....

• Complications: .....

• Graft date: .....

**Skin:** • Total time needed for reepithelialization: .....

• Complications: .....

• Graft date: .....

• Healing quality: .....

■ **Middle term** Observation date (day/month/year): .....

**Eye:** • visual acuity: Right eye: ..... Left eye: ..... Binocular: .....

• grade: ☐ absence of visible lesion ☐ I ☐ II ☐ III ☐ IV

• Total time needed for reepithelialization: .....

• Complications: .....

• Graft date: .....

**Skin:** • Total time needed for reepithelialization: .....

• Complications: .....

• Graft date: .....

• Healing quality: .....

■ **Long term** Observation date (day/month/year): .....

**Eye:** • visual acuity: Right eye: ..... Left eye: ..... Binocular: .....

• Final healing quality: .....

**Skin:** • Total length of time needed for total reepithelialization: .....



# PRACTICAL SOLUTIONS AND TOOLS FOR CHEMICAL RISK MANAGEMENT AND PREVENTION

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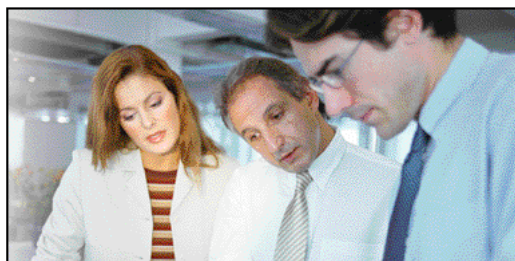
Emergency washing  
of chemical splashes



Management  
of accidental  
chemical spills



Chemical risk  
management training  
for professionals in  
the field of prevention



Technical manuals  
and training sessions  
for chemical risk  
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