Major Hazards Exist in Many Industries

"On the subject of disasters, it is very common…to say 'this won't happen'. I have sympathy with this. What they really mean is, it's highly improbable. And they're right: it is highly improbable…This creates a kind of vacuum in terms of what to focus on so it's easier to say, either out loud or in your private thoughts, 'this won't happen'.

The way to avoid this trap is to say, yes, it will happen. It will happen to somebody, somewhere, at some point in time. That's all but guaranteed. Now, what are we going to do to make sure it doesn't happen to us? It's a subtle but profound shift in thinking."

Kevin Lacy, "The Road to High Reliability"

https://suzannecgordon.com/2014/05/30/the-road-to-high-reliability/

Toxic Release Video

https://www.csb.gov/mgpi-processing-inc-toxic-chemical-release-/

Layers of Protection

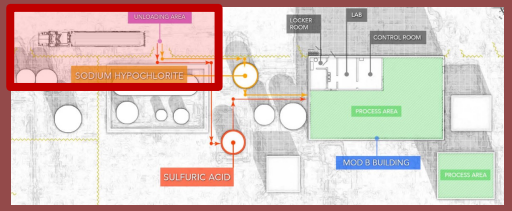
Automation and remote shutdown

Barbed wire gate

Locked Dust Cap

Operator observe hose connection and open MGPI valve

Unique connection fittings



- What if the wrong connection was an **intentional** act?
  - How might your analysis change?

Toxic Release Video

*"Each year, people around the world lose their lives due to the lack of proper training and recognition of chemical **process safety**. These incidents also result in injuries and environmental and facility damage. Although international recognition of the importance of chemical **process safety** is growing, only a few centers of expertise exist."* **– Purdue Process Safety and Assurance Center**

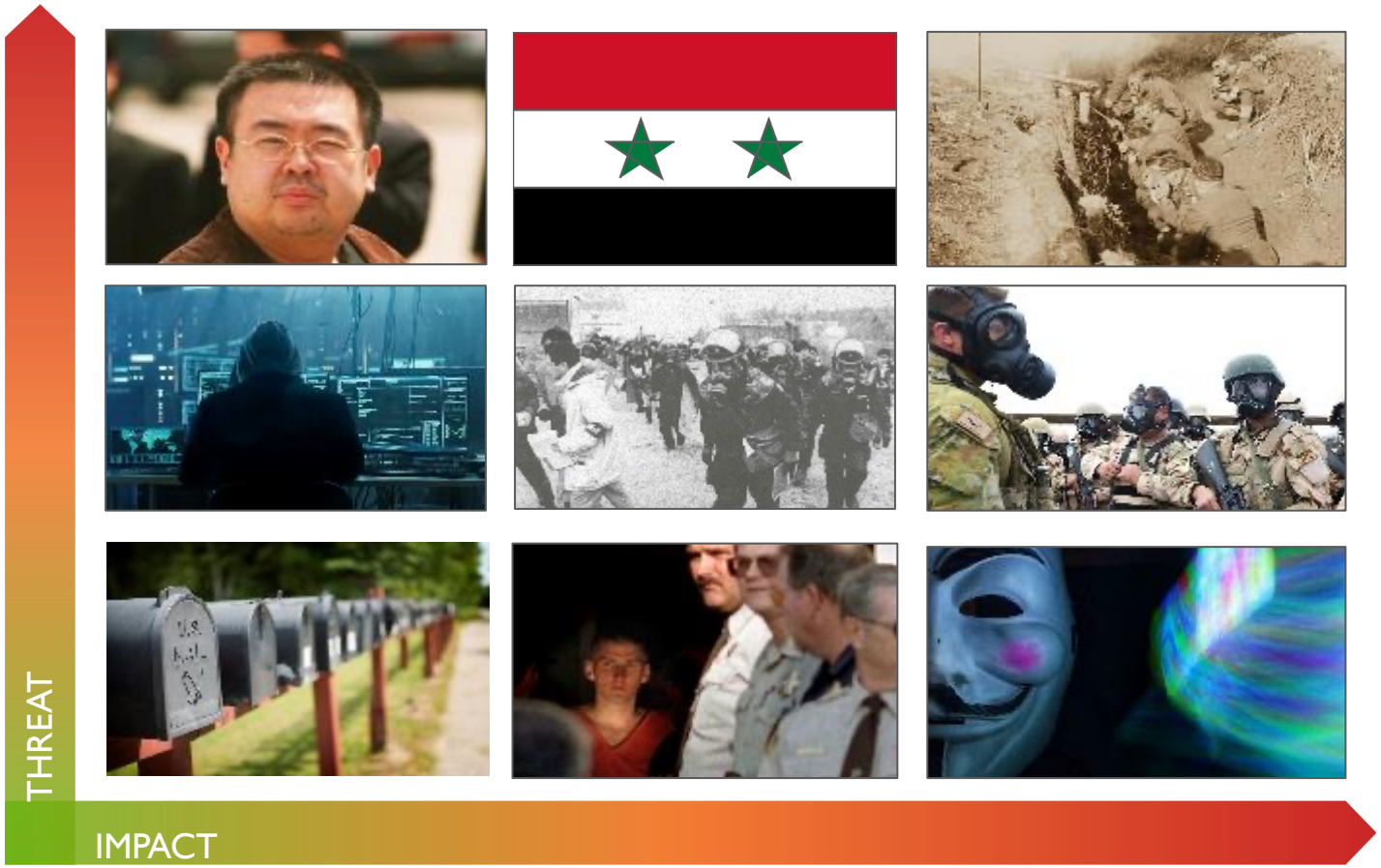
Each year, people around the world *may* lose their lives due to the lack of proper training and recognition of chemical **security**. These incidents also result in injuries and environmental and facility damage. Although international recognition of the importance of chemical **security** is growing, only a few centers of expertise exist.

A variety of threats can attempt to misuse chemicals

STATE OR GOVERNMENT

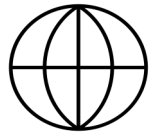
ORGANIZED GROUP

INDIVIDUAL



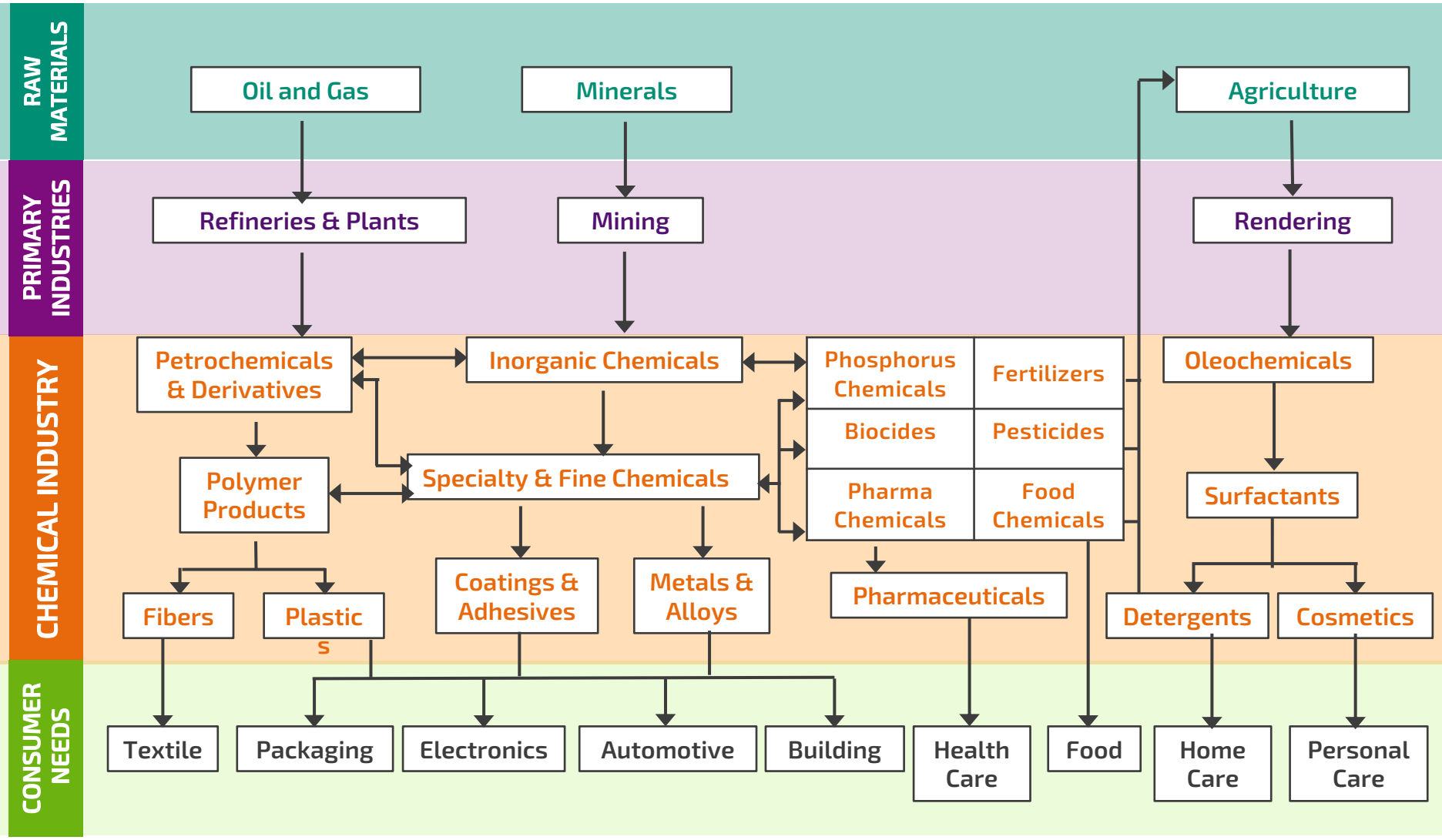
INDIVIDUAL
(Poisoning, assassinations, etc.)

LOCALIZED



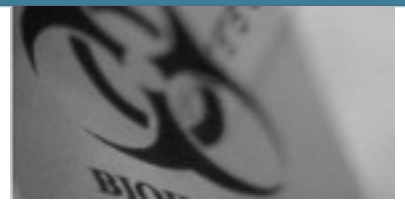
WIDESPREAD

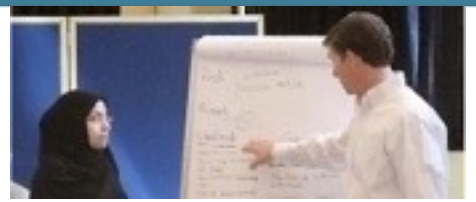
Relation Between Chemicals and Certain Industries



Adapted from Zanbak

Learning from Other Sectors: Introduction to Chemical Security






Mo Payne, PhD

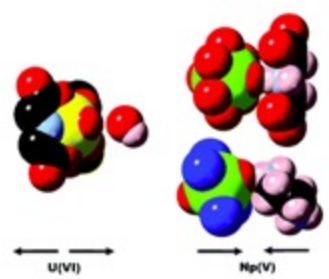
P2SAC Spring Conference

9 May 2022

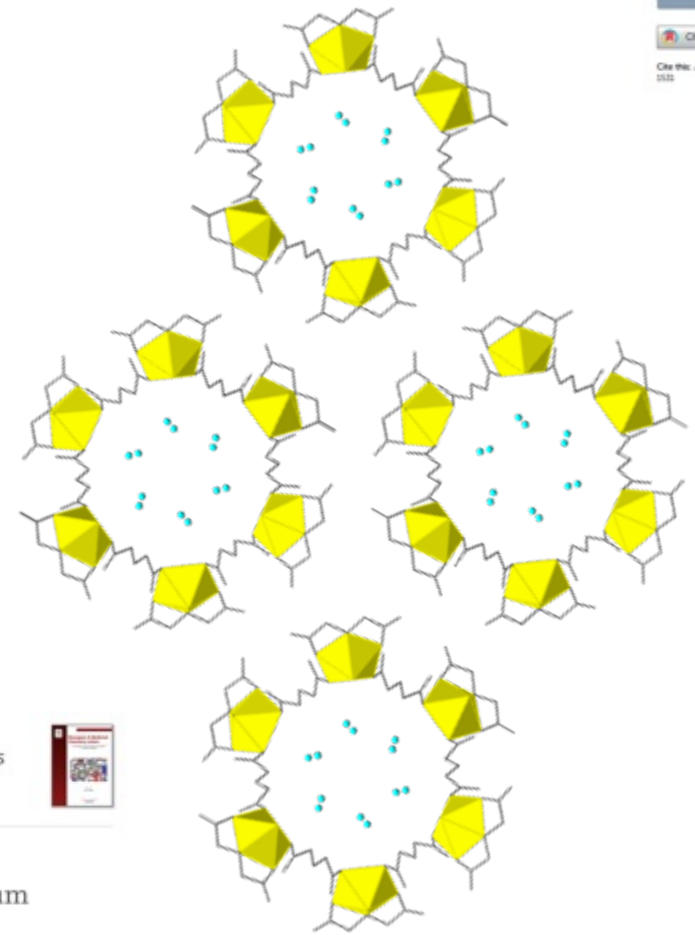
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

SAND2022-6204

Dr. Payne's Background



THE UNIVERSITY OF IOWA



Journal of Materials Chemistry A

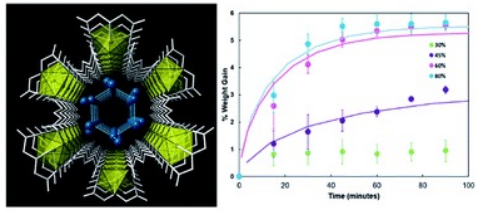
PAPER

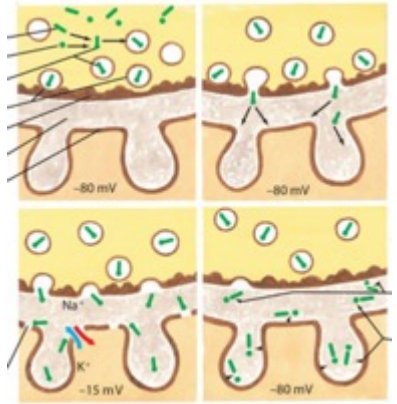
View Article Online

Check for updates

Diffusion and selectivity of water confined within metal–organic nanotubes.†

Ashini S. Jayasinghe, Maurice K. Payne, Daniel K. Unruh, Adam Johns, Johna Leddy* and Tori Z. Forbes*





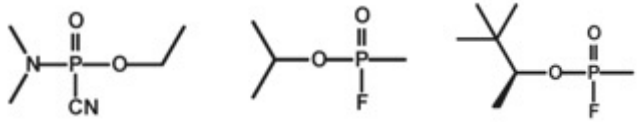
Medical Aspects of Chemical Warfare. TMM Publications: Washington, DC: 2008

ELSEVIER

Bioorganic & Medicinal Chemistry Letters
Volume 23, Issue 21, 1 November 2013, Pages 5786-5789

Reversible inhibition of human acetylcholinesterase by methoxypyridinium species

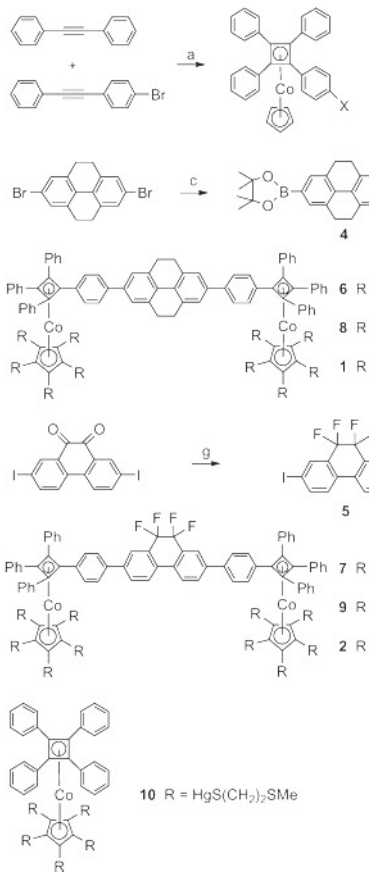
Joseph J. Topczewski, Alexander M. Lodge, Sumana N. Yasapala, Maurice K. Payne, Pedrom M. Keshavarzi, Daniel M. Quinn *



Dr. Mulcahy's Background

Highschool Teacher

Ph.D., University of Colorado at Boulder



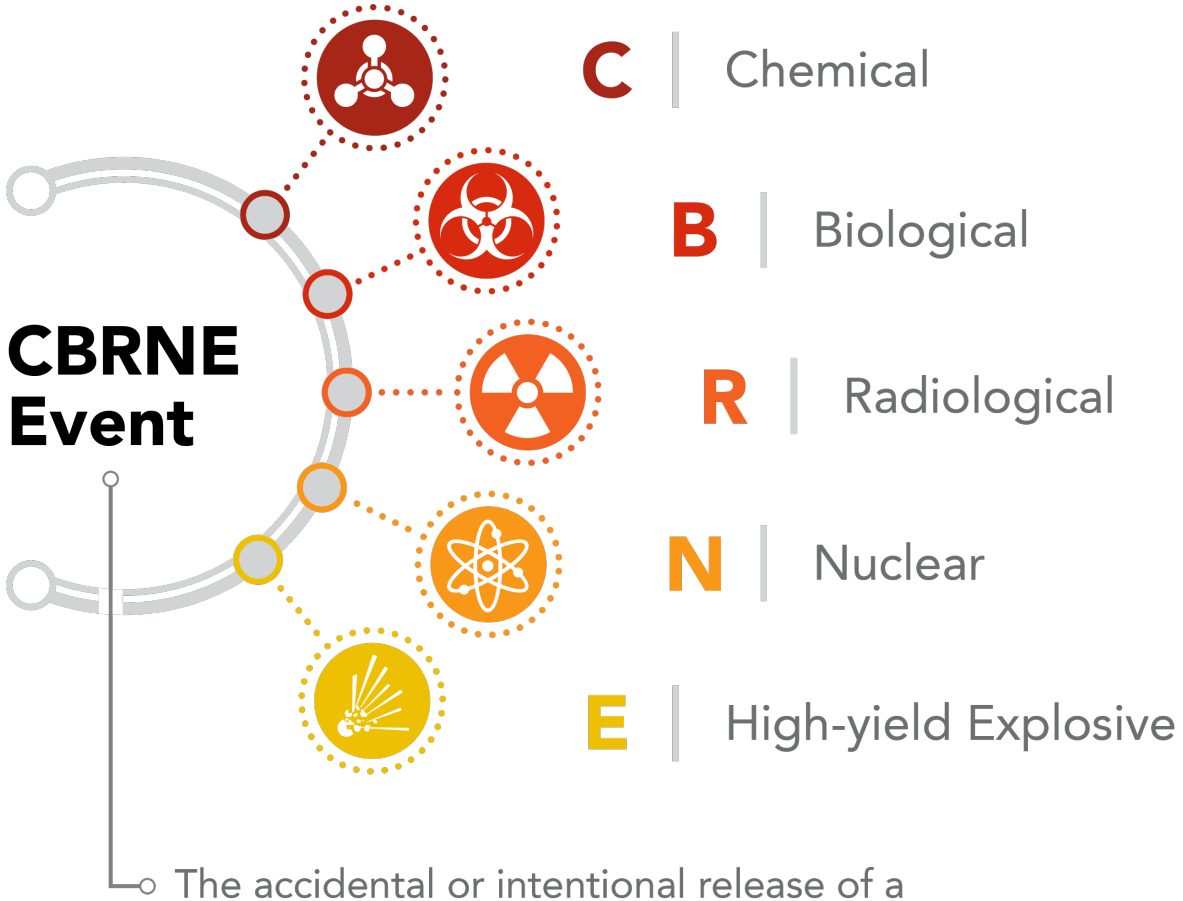
NSF International Research Fellowship

US Chemical Safety Board Major Accident Investigations

Sandia National Laboratories & ACS EIC

Global Chemical and Biological Security

Sandia National Laboratories
Albuquerque, New Mexico, USA



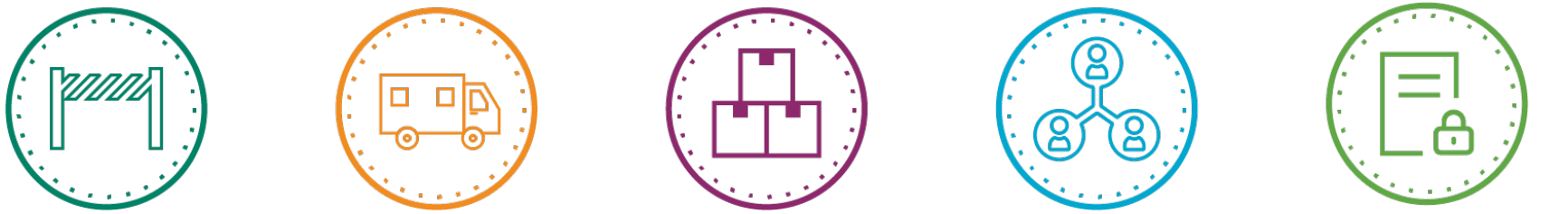
The accidental or intentional release of a hazardous material that poses a threat to life, property, and/or the environment.

Global Chemical and Biological Security (GCBS)

Innovative solutions for countering chemical and biological threats

Reduce the risk of intentional removal (theft), release, or sabotage of a valuable or hazardous chemical or biological material

- Implement comprehensive security program
- Support safety and security best practices



Global Experience

Chemical Safety—Unintentional

Chemical Safety vs Chemical Security

Chemical Weapons Historical Moments

600 BCE
Athenian military poisoned the water supply of Kirrha with hellebore plants.

479
Peloponnesian army used sulfur fumes against the city of Plataea.

1845
French troops force more than a 1,000 Algerian Berbers into a cave and used smoke to kill them.

1861–1865
Both sides in the American Civil War proposed using poisonous gas against each other.

Photo credits – Wikimedia Commons, Pixabay

Chemical Weapons

Chemical storage area

Advantages of chemical weapons

- Chemical precursors and toxic industrial chemicals often are readily available and relatively inexpensive
  - Access to precursors may not be regulated in some countries
- Technology to make traditional and improvised chemical weapons is available in open literature

Disadvantages of chemical weapons

- Require significant quantities to produce mass casualties
- Risk of exposure of personnel during manufacture and/or weapon delivery

Choking Agents

SIGNS AND SYMPTOMS

Range from irritation of eyes, nose, and throat to airway constriction and fluid accumulation in the lungs

Blood Agents

SIGNS AND SYMPTOMS

Range from skin and eye irritation and rapid/deep breathing to convulsions, loss of consciousness, and death.

Blister Agents

SIGNS AND SYMPTOMS

Includes blisters; eye, nasal, and sinus pain; tissue damage

SIGNS AND SYMPTOMS

Range from contraction of pupils and excessive salivation to convulsions
and death by asphyxiation

Nerve Agents

Chemical Weapons Historical Moments

Allied casualties from mustard gas

Photo credit - United Kingdom Government

World War I

French troops use tear gas grenades against the Germans.

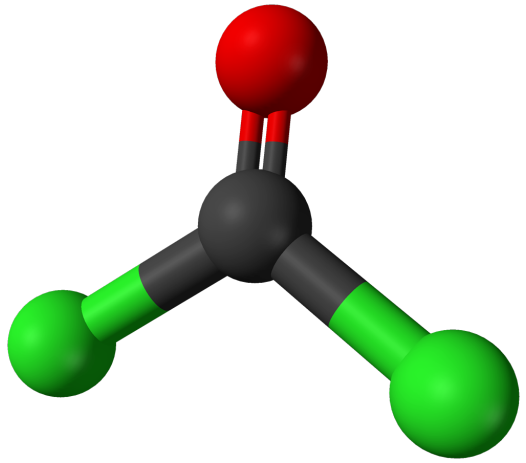
German military uses nearly 170 tons of chlorine gas at Ypres, Belgium. 1,100 troops killed and 7,000 injured.

Mustard gas is used for the first time by the German military. This caused more than 2,100 Allied casualties.

1914-15 1917 1918 1925 1935-36 1939-45 1962-67 1980-88 1993 1994-95 2013–

Results of Chemical Weapons During WW1

At the conclusion of WW1 (Nov. 11, 1918) there were 1.3 million casualties from chemical weapons and between 90,000 and 100,000 deaths. These deaths were mainly from the industrial chemical phosgene.



Used to make plastics and pesticides.

A gas at room temperature (70 F).

Its lethal concentration of 0.1% can be visible as a green cloud in the air.

Causes noncardiogenic pulmonary edema.

Science History Institute, Distillations, A Brief History of Chemical War, Sarah Everts, Spring 2015.

Chemical Weapons Historical Moments

Auschwitz Birkenau concentration and extermination camp

Photo credit – Wikimedia Commons

1939-1945

During WWII the Germans use poison gases as chemical weapons at Nazi concentration camps to kill civilians.

The Japanese also use chemical weapons against Chinese military forces and civilians.

Chemical Weapons Historical Moments

1980-1988

During the Iran-Iraq war the Iraqi military forces use tabun (nerve agent) and mustard against Iranian forces and Iraq's Kurdish minority.

Over 100,000 Iranian troops and significant numbers of civilians became victims of chemical weapons.

This period was the largest chemical weapon attack against a civilian population.

1914-15 1917 1918 1925 1935-36 1939-45 1962-67 1980-88 1993 1994-95 2013–

Chemical Weapons Historical Moments

Subway cleanup after deadly Aum Shinrikyo sarin attacks in 1995

1994–95

Aum Shinrikyo was a doomsday cult that began in Japan in the 1980's and grew to amass up to $1 billion in assets by the 1990's.

The group spent upwards of $30 million to research chemical and biological weapons.

They successfully synthesized many chemical weapons. Ultimately their efforts led to nerve gas attacks in Matsumoto (1994) and the Tokyo Subway System (1995).

Flashback to Aum Shrinrikyo
Sarin attacks of 1995

https://www.nbcnews.com/video/flashback-tokyo-subway-sarin-attack-415011907619

Poll

When would you guess the first chemical weapons ban between two counties was implemented?

1. 1675
2. After WWI
3. After WWII
4. 1980's

Chemical Weapons From 500 Years Ago to WWI

1500

1600

1675
First chemical weapon ban

1700

1760
Industrial Revolution begins

1800

1806
"Organic chemistry" coined as a field of study

1810-1822
Chlorine, phosgene, and mustard gas discovered

1863
Lieber Code of Conduct

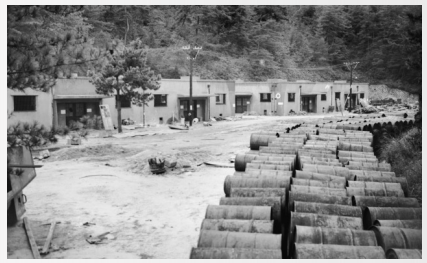
1874
Brussels Declaration

1899
The Hague Convention

1900

WWI

CHEMICAL WARFARE BEGINNINGS



Chemical Weapons: WWI to 1980

1980
Negotiations begin for Chemical Weapons Convention

1952
Dr. Ranajit Ghosh discovers VX while researching pesticides

1950

1937
Gerhard Schrader discovers Tabun while researching pesticides

1947
Britain, Canada and the US sign a Tripartite Agreement

1925
The Geneva Protocol

1935
Germany requires chemists to report chemicals that could have warfare applications

1900

1914-1918, WWI Arms Race for Chemical Weapons Begins

Global Arms Race: advanced chemical weapons research programs – organophosphate nerve agents

Chemical Weapons: Iraq-Iran War to Early 2000s

1980

1980 - 1988
Iraq – Iran War

1985
Australia Group
established

1993
Chemical Weapons
Convention (CWC)
signed

1994, 1995
Aum Shinrikyo sarin attacks

2000

OPCW

The Australia Group

Chemical Weapons: Iraq-Iran War to Early 2000s

1980

1980 - 1988
Iraq – Iran War

1985
Australia Group established

1993
Chemical Weapons Convention (CWC) signed

1994, 1995
Aum Shinrikyo sarin attacks

1997
CWC goes into affect

2000

OPCW

The Australia Group

The Organisation for the Prohibition of Chemical Weapons
OPCW

Current Membership: State Parties to the Convention: **193** Signatory States: **1** Non-signatory States: **3** Percent of World Population Protected: **98%** 	Declared stockpiles destroyed: **99%** 
Chemical Weapons Production Facilities Declared: **97** Destroyed: **74** Converted for peaceful purposes: **23**	Industry Facilities Subject to Inspection: **4,916**

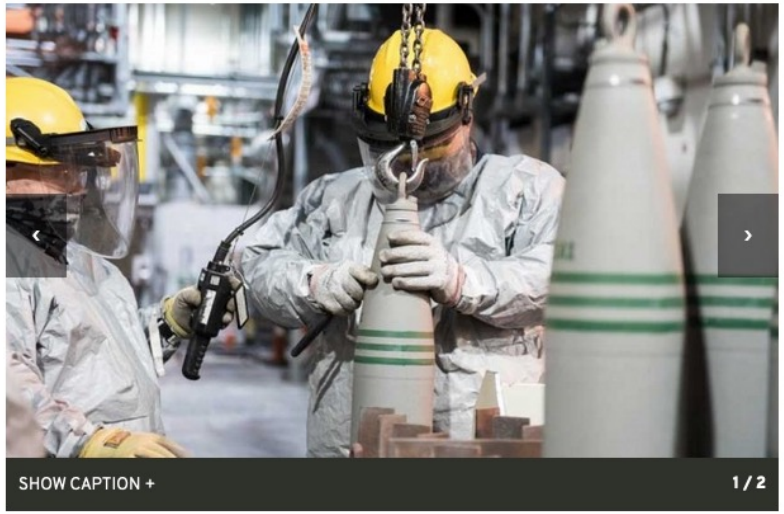
As of January 31, 2022 https://www.opcw.org/media-centre/opcw-numbers

US signed the CWC in 1993 and ratified in 1997

- The United States declared a large chemical arsenal of 27,770 metric tons to the OPCW after the CWC came into force in 1997
- Along with Russia, the United States received an extension when it was unable to complete destruction of its chemical stockpiles by 2012
- We are scheduled to complete destruction in 2023

Army continues work to dispose of chemical weapons

By James Campbell January 18, 2022



ABERDEEN PROVING GROUND, Md. – Destruction of the U.S. chemical weapons stockpile located in two states has reached the 75% completion mark, with a combined total of more than 2,352 U.S. tons of chemical agent destroyed as of Jan. 14, 2022.

Arms Control Association, Chemical and Biological Weapons Status at a Glance,https://www.armscontrol.org/factsheets/cbwprolif
https://www.army.mil/article/253326/army_continues_work_to_dispose_of_chemical_weapons

CHEMICAL WEAPON AGENTS AND PRECURSORS

Three lists ("Schedules") of chemicals subject to monitoring and verification

Schedule	Criteria	Commercial Uses	Chemical Weapon Proliferation Risk
1	• Historically used as a CW • Closely related to other schedule 1 chemical • Final stage precursor to schedule 1 chemical • Lethal or incapacitating properties	Few	High Risk
2	• Final stage precursor to schedule 1A or 2A chemical • Lethal or incapacitating properties	Moderate	Significant Risk
3	• Precursor to schedule 1B or 2B chemical • Historically used as a CW • Lethal or incapacitating properties	Extensive	Risk

SCHEDULED CHEMICALS UNDER THE CHEMICAL WEAPONS CONVENTION

Three lists ("Schedules") of chemicals subject to monitoring and verification

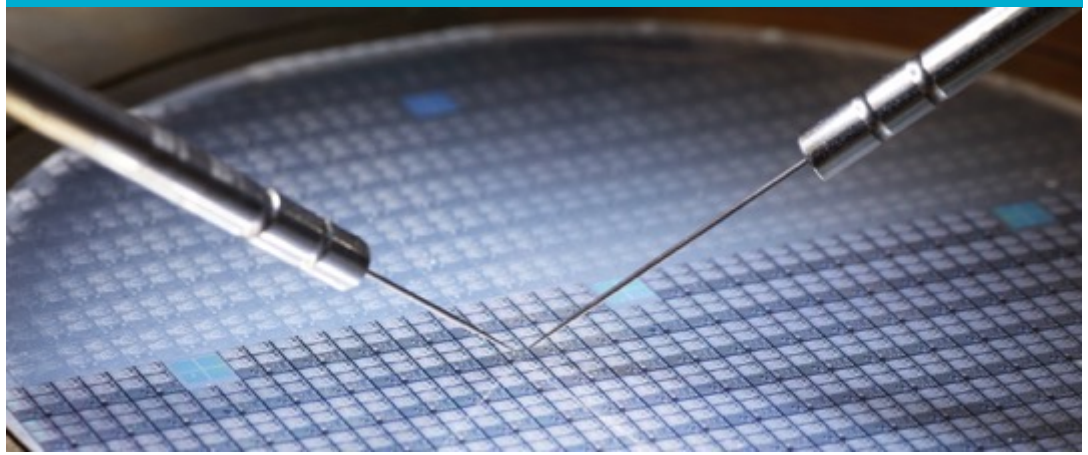
SCHEDULE	
1	A. Nerve and blister agents: sarin, tabun, sulfur mustard, lewisite B. Final step nerve agent precursor chemicals (binary precursors)
2	A Insecticide and nerve agent Amiton and incapacitating agent BZ B Arsenic trichloride and select phosphorous and nitrogen compounds
3	A. Choking and blood agents: phosgene and hydrogen cyanide B. Select phosphorous and nitrogen compounds like phosphorous trichloride and triethanolamine

SCHEDULE 1 TOXIC CHEMICALS AND PRECURSORS IN INDUSTRY

There are very limited legitimate uses for chemicals found on Schedule 1 (A or B). Generally you should not encounter these chemicals in modern industry.

SCHEDULE 2 TOXIC CHEMICALS AND PRECURSORS IN INDUSTRY

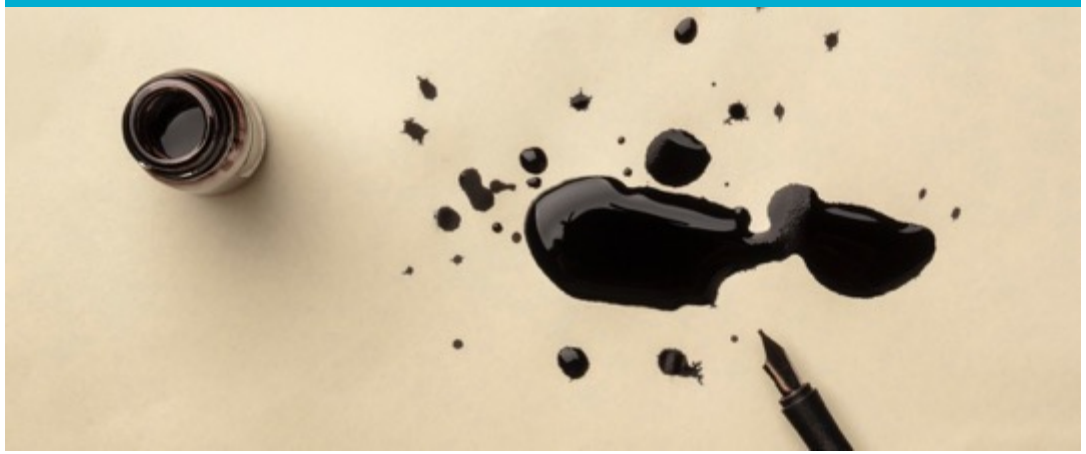
Perfluoroisobutylene (PFIB)



is an example of a **schedule 2A** toxic chemical

- Colorless odorless gas
- Acutely toxic
- Used in chemical synthesis and semiconductors

Thiodiglycol



is an example **schedule 2B** precursor chemical

- Viscous, colorless liquid
- Odor of rotten eggs
- Used in ink manufacturing and as a solvent for dyes
- Not very toxic, only mildly irritating

SCHEDULE 3 TOXIC CHEMICALS AND PRECURSORS IN INDUSTRY

Cyanides like hydrogen cyanide (HCN) and cyanogen chloride (CNCl)

are examples of **schedule 3A** toxic chemicals

- Colorless gas or liquid with pungent odor
- HCN was main ingredient of Zyklon B, the chemical weapon used by the Nazis in WWII gas chambers
- HCN used in production of nylon, plastics, and paints
- CNCl used in metal cleaners, ore refining, and herbicides

Phosphorous trichloride (PCl_3)

is an example schedule 3B precursor chemical

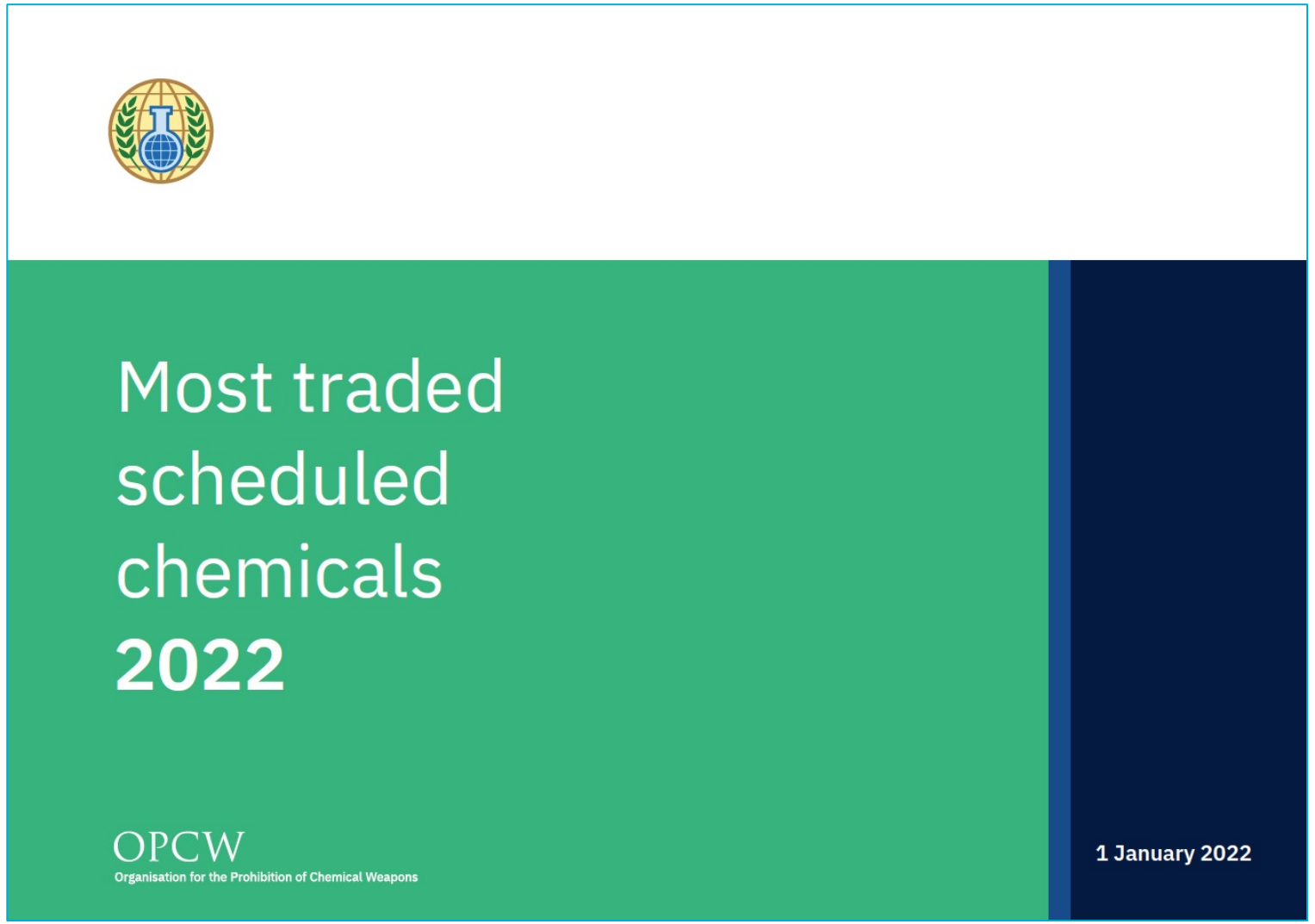
- Clear fuming liquid
- Acutely toxic and corrosive
- Found in flame retardants, pharmaceuticals, and textile finishing agents
- Amount traded in 2020: $90,000,000+

CHEMICAL WEAPON AGENTS & PRECURSORS SUMMARY

Weapon Agent	Common Types of Precursors	Industry Uses
Choking	Chlorine compounds	Water treatment, plastics, pharmaceuticals, dyes, pesticides
Blood	Cyanide compounds	Mining, metallurgy
Blister	Nitrogen, sulfur, arsenic compounds	Plastics, rubber, dyes, textiles, batteries, pharmaceuticals, lubricants, detergents, cosmetics, ceramics
Nerve	Phosphorous and fluorine compounds	Pesticides, flame retardants, lubricants, water treatment, cleaning, plastics, semiconductors

CWC SCHEDULED CHEMICALS ARE USED IN NUMEROUS INDUSTRIES.

This document is updated every few years



CWC scheduled chemicals are used in numerous industries.

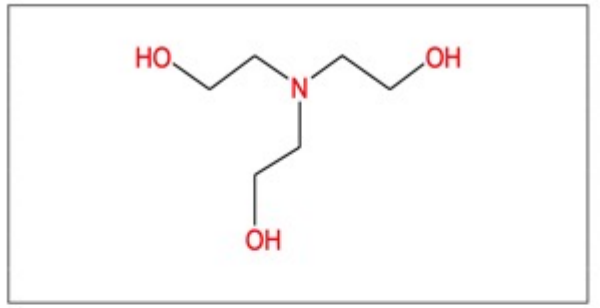
Worldwide trade of this chemical was over $270,000,000 in 2020

Chemical Name:	**Triethanolamine**
CAS RN:	102-71-6
Schedule:	3B17
HS code:	2922.15
Molecular Formula:	C6H15NO3
CAS Index Name:	Ethanol, 2,2',2"-nitrilotris-
IUPAC Name:	2,2',2"-Nitrilotriethanol
Synonyms:	Trolamine Tis-(2-Hydroxyethyl)amine Tris(beta-hydroxyethyl)amine Tris(2-hydroxyethyl)amine Triethanolamin TEOA TEA (amino alcohol) TEA Sting-Kill Sterolamide Nitrilotriethanol Daltogen Alkanolamine 244 2,2',2"-Nitrilotris[ethanol]

Used as corrosion inhibitor; used in gas purification processes, metal working, mining, petroleum and coal, polymers, textiles, pigment dispersion, pesticides and herbicides.

Applications include: coating technology, metal coating preparations, glass coating (shatter proofing, anti-frosting, antifogging and-dirt resistant films on glass and plastics); also used as accelerator for photo-polymerisation coating (improves thermal properties and reduces cracking in prepared wire coatings).

Chemical Structure



Commercial Applications & Industrial Uses

Used in production of emulsifiers, detergents, textile and leather chemicals, drilling and cutting oils (impregnating materials, soaps, cosmetics and toiletries, agricultural products, pharmaceuticals).

Used in production of: cleaners (all-purpose cleaners, cleaners that involve skin contact because of mildness of this chemical, waterless hand cleaners), cement and concrete (as s milling additive) and adhesives.

Used in wax formulations: cream waxes and polishes used for furniture, floors and automotive car wax.

Moving Beyond CWC Scheduled Chemicals

Toxic Industrial and Agricultural Chemicals

- Have widespread legitimate uses
- Dual-use and multi-use chemicals
- Available in large quantities
- Pose a variety of acute exposure hazards

Pharmaceutical-Based Agents

- These agents are an emerging threat
- Chemicals initially developed for legitimate uses
- Toxicity can be very high even at very low doses

Pharmaceutical-Based Agents
Moscow Theater Attack

In 2002 violent separatists held 800 people hostage in a Moscow theater.

- Russian special forces used an opioid to incapacitate the terrorists
- Over 120 hostages died with 600 more requiring hospitalization

"The agent whereby people could be incapacitated without risk of death in a tactical situation does not exist and is unlikely to in the forseeable future. In such a situation***, it is and will continue to be almost impossible to deliver the right agent to the right people in the right dose without exposing the wrong people or delivering the wrong dose***." – British Medical Association Board of Science, The use of drugs as weapons: The concerns and responsibilities of healthcare professionals, London: BMA, May 2007

Chemical Security Concepts

Principles of Physical Security

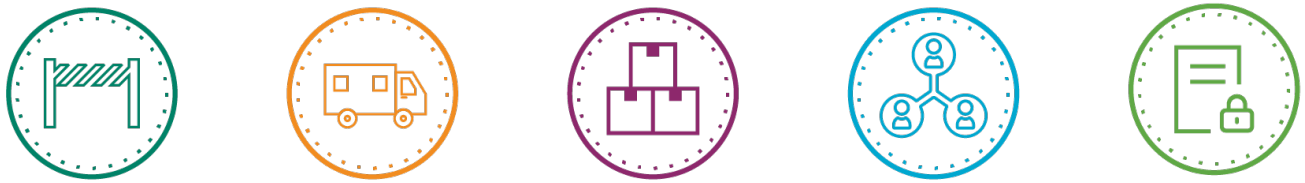
PHYSICAL SECURITY

DETECT	DELAY	RESPOND
The ability to identify adversaries attempting to access the facility.	Barriers designed to slow down an adversary until responders can assess and intervene	Respond and stop an adversary or to protect workers and the surrounding community.
		

Other important aspects of physical security are **Access Control** and **Deterrence.**

Security Posture

Security Posture	Exemplar Descriptions	Accessibility Ranking
Low:	No Security Measures Implemented.	High
Medium:	Notable security gaps allow opportunity for adversary to be successful; detection and delay do not provide sufficient time for response to arrive OR no response plan has been developed.	Medium
High:	Security gaps are minimal; detection and delay may allow for sufficient time for response to arrive under ideal conditions AND/OR response force probably has sufficient skills and resources to neutralize the threat	Low
Very High:	Security is robust; there are minimal gaps; detection and delay allow for sufficient time for response to arrive under extraordinary conditions AND response force is more likely than not to neutralize the threat	Very Low



What Are The Risks To Selling Chemicals?

What are the risks to selling chemicals?

Illicit sorbitol case study

- Sorbitol is a white solid or concentrated clear solution
  - often used as a sugar substitute in sweets
  - used in cosmetics and some medical applications
  - Also a main ingredient in solid rocket propellant
- ISIS procured tons of sorbitol to use in rockets
  - many provinces in Iraq have seen sorbitol used this way

WHAT CAN HAPPEN IF YOU DON'T TRACK NORMAL BUSINESS PRACTICES?

Illicit sorbitol case study

Sorbitol manufactured by French company 'Tereos' in 2015

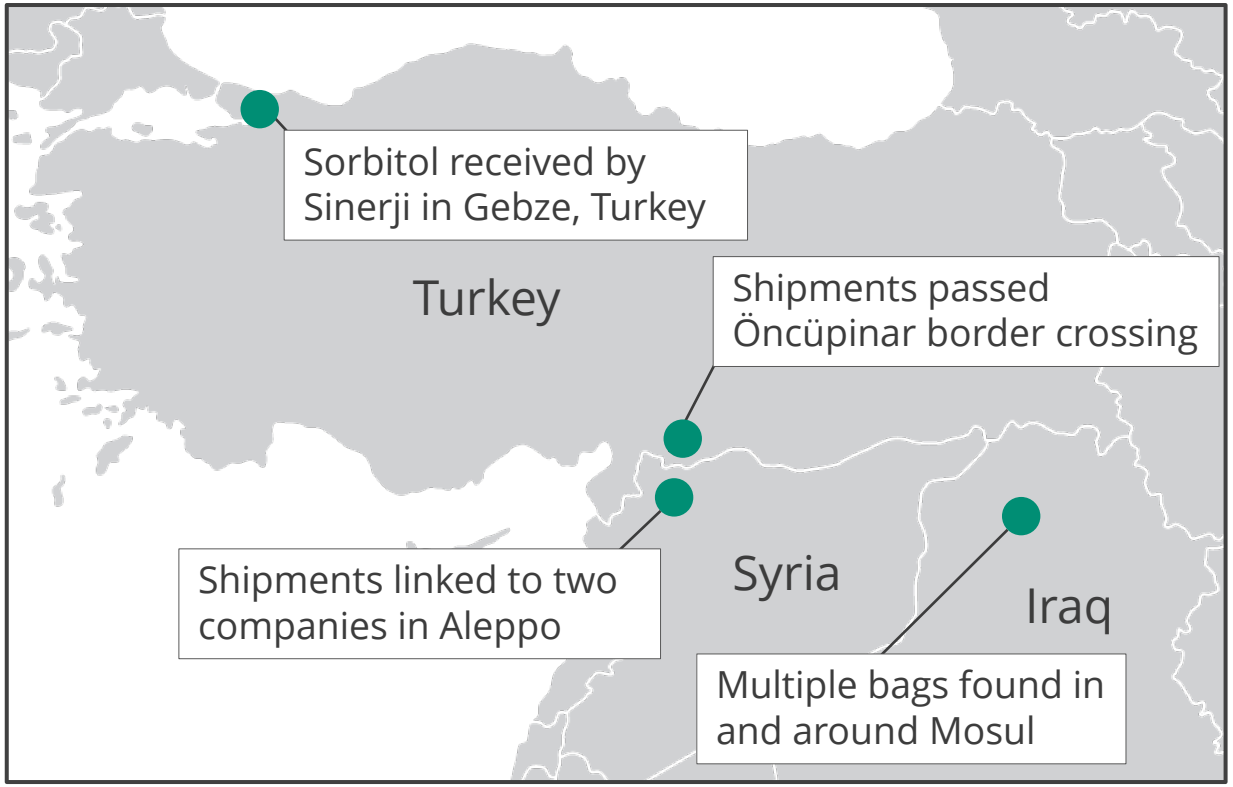
Lot numbers on ISIS bags associated with the following companies who purchased from Tereos:

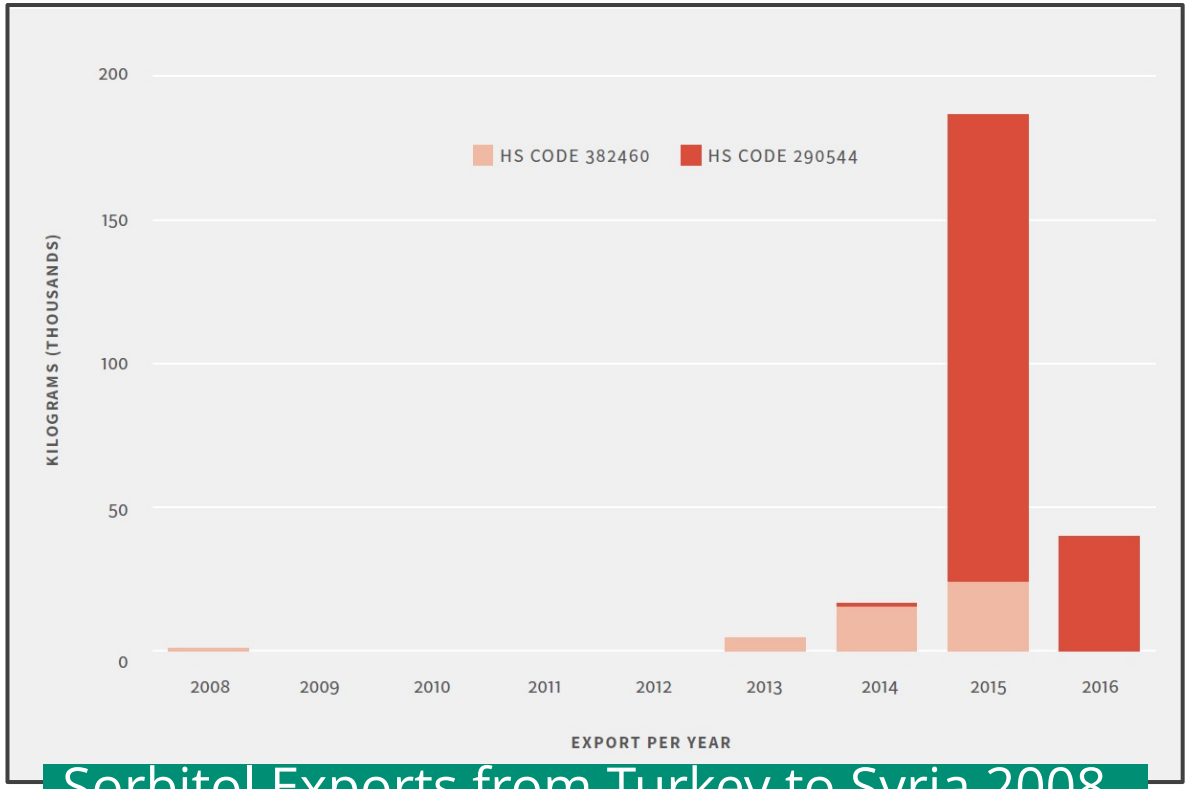
- **Ceremony**, confectionary manufacturer in Turkey
- **Kent**, chewing gum production facility in Turkey
- **Eurosweets GmBH**, sugar based liquid manufacturer in Germany
- **Animal Lovers**, Dutch pet food maker
- **Sinerji**, official Tereos distributor in Turkey
  - Sinerji shipped 78 tons to two Syrian companies

Sorbitol found at ISIS weapons site in Tal Afar, Iraq (Sept 2017)

What can happen if you don't track normal business practices?

Illicit sorbitol case study



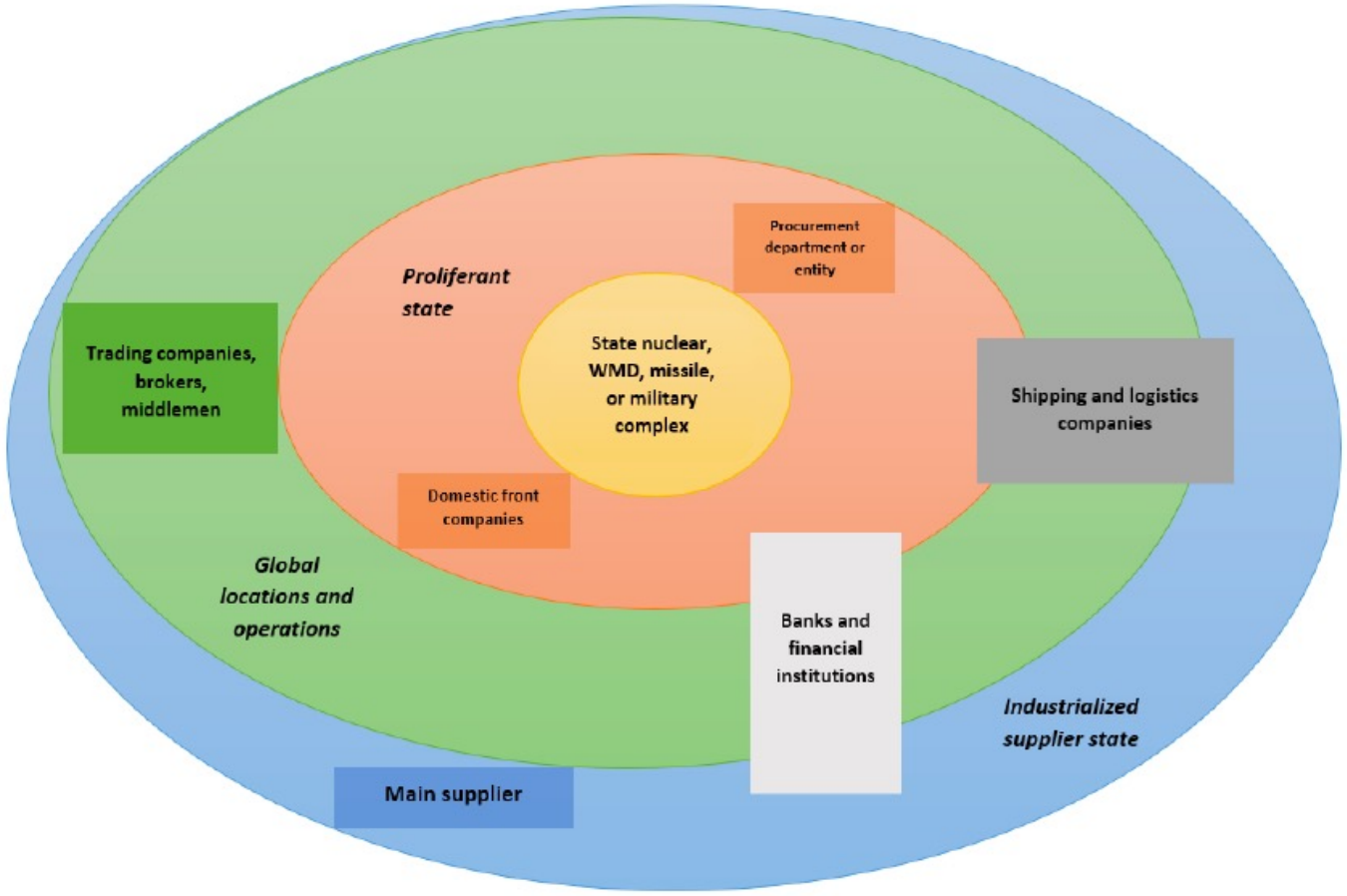


Sorbitol Exports from Turkey to Syria 2008-2016

Illicit Chemical Procurement Networks

Network structures will vary

- They exist to circumvent the frameworks in place to prevent chemical proliferation
- They are always made up of many entities and individuals
  - Entities may exist only very briefly

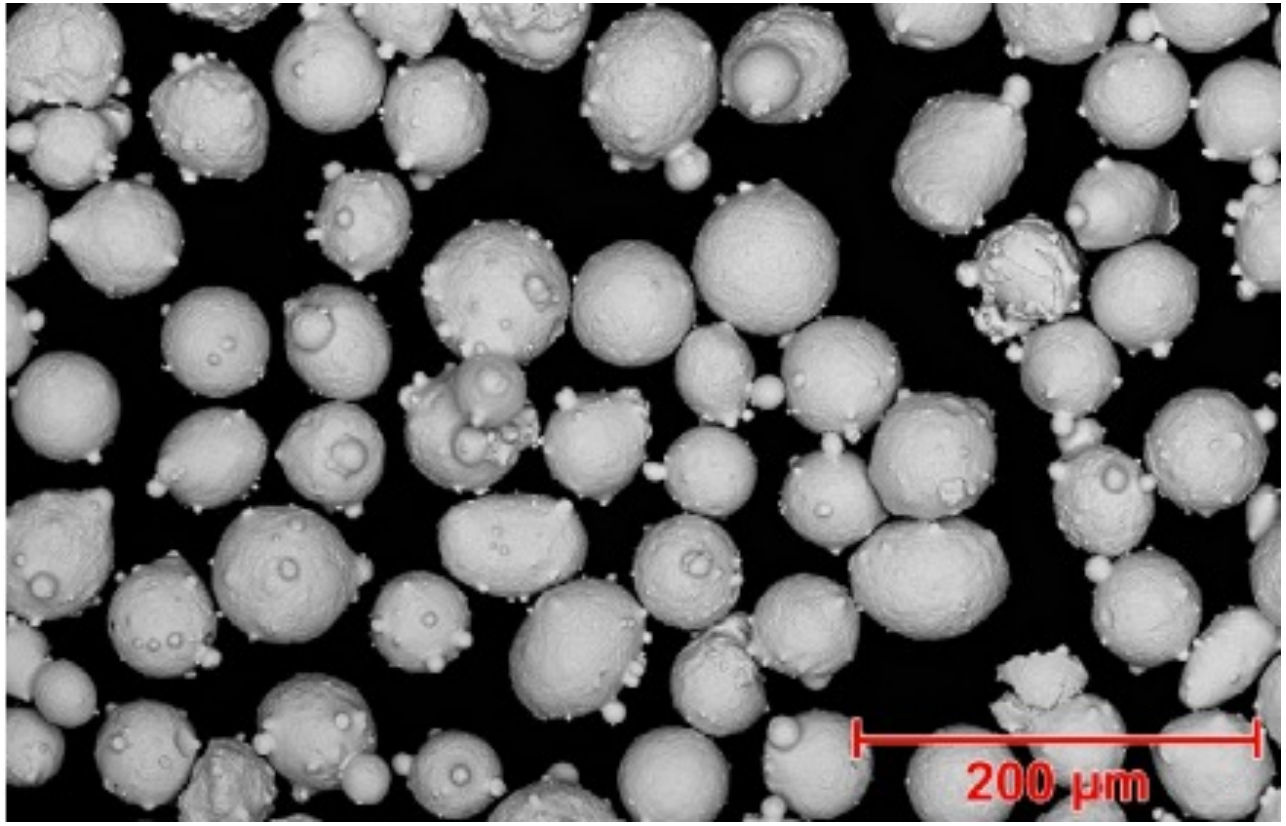


The bad actors are always trying to find ways to procure chemicals

Figure: *Illicit Trade Networks,* Albright, Burkhard, Faragasso, Keenan, Stricker; Institute for Science and International Security, 2020

Illicit Chemical Procurement Networks

Metal Powders Case Study



Quick Facts	
Classification	Alloys, cobalt-based
Chemistry	Co 32Ni 21Cr 8Al 0.5Y or Co 29Cr 6Al 2Si 0.3Y
Manufacture	Gas atomized
Morphology	Spheroidal
Purpose	Oxidation and / or hot corrosion resistance

1.1 Typical Uses and Applications

Generally used as a thermal sprayed coating for:

- Oxidation and hot corrosion resistance on gas turbine components such as airfoils, turbine buckets, turbine blades and shrouds
- Corrosion resistant bond coat layer for thermal barrier coatings and ceramic clearance control coatings
- Exhaust manifolds, ducts and components used in flue gas and fly ash systems

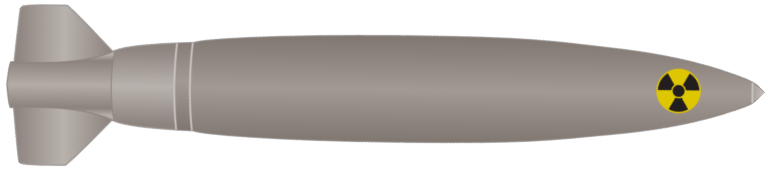


Image source (company is unrelated to case study): https://www.oerlikon.com/ecomaXL/files/metco/oerlikon_DSM-0247.0_CoCrAlY_CoNiCrAlY.pdf&download=1

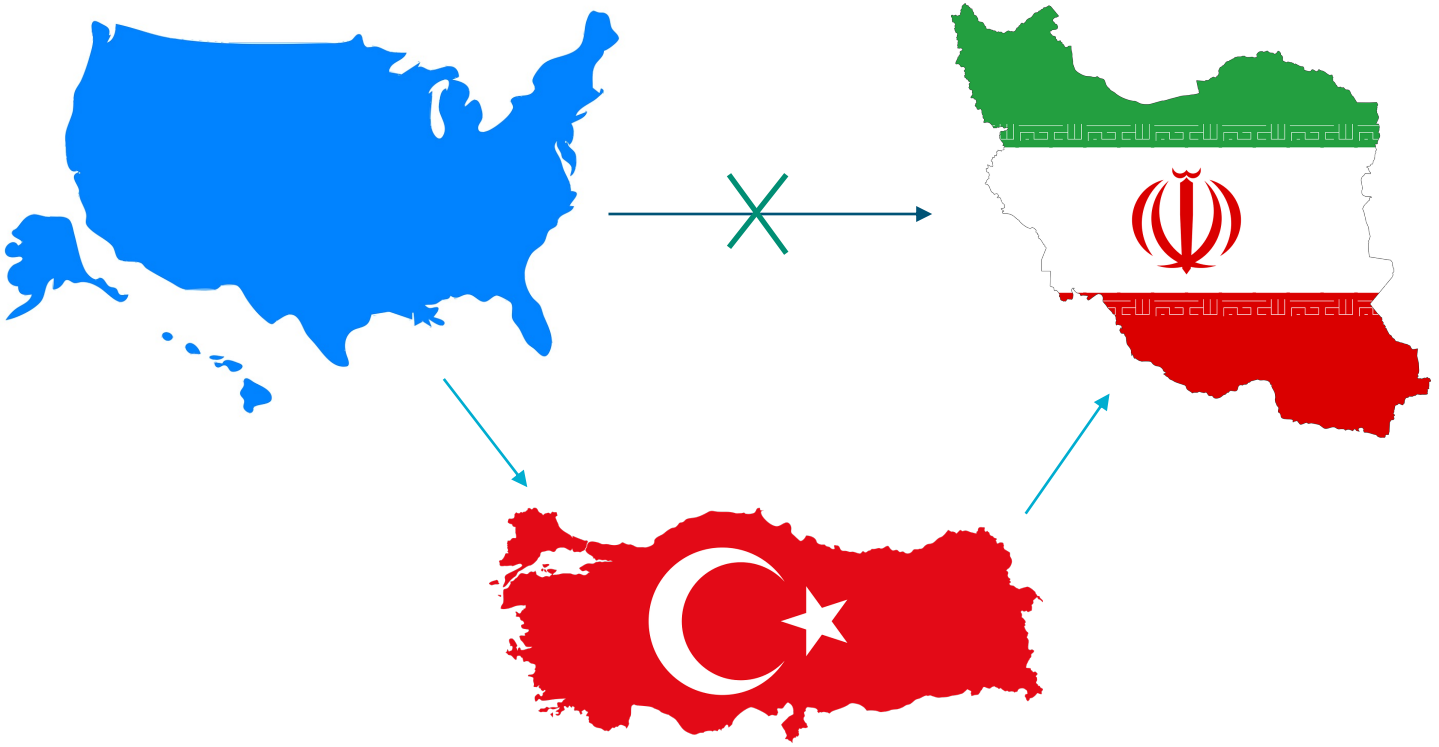
Illicit Chemical Procurement Networks

Metal Powders Case Study

What happened?

- The export of the metal powders was a violation of U.S. sanctions on Iran
- The transaction was disguised to avoid raising suspicions

The CEO of a U.S. company that completed a sale pleaded guilty and was sentenced to 57 months in prison



https://www.justice.gov/usao-edny/pr/ceo-international-metallurgical-company-sentenced-57-months-prison-conspiring-export
United States District Court in the Eastern District of New York, Case No. 1:16-cr-00308-DLI, Available at Pacer.gov

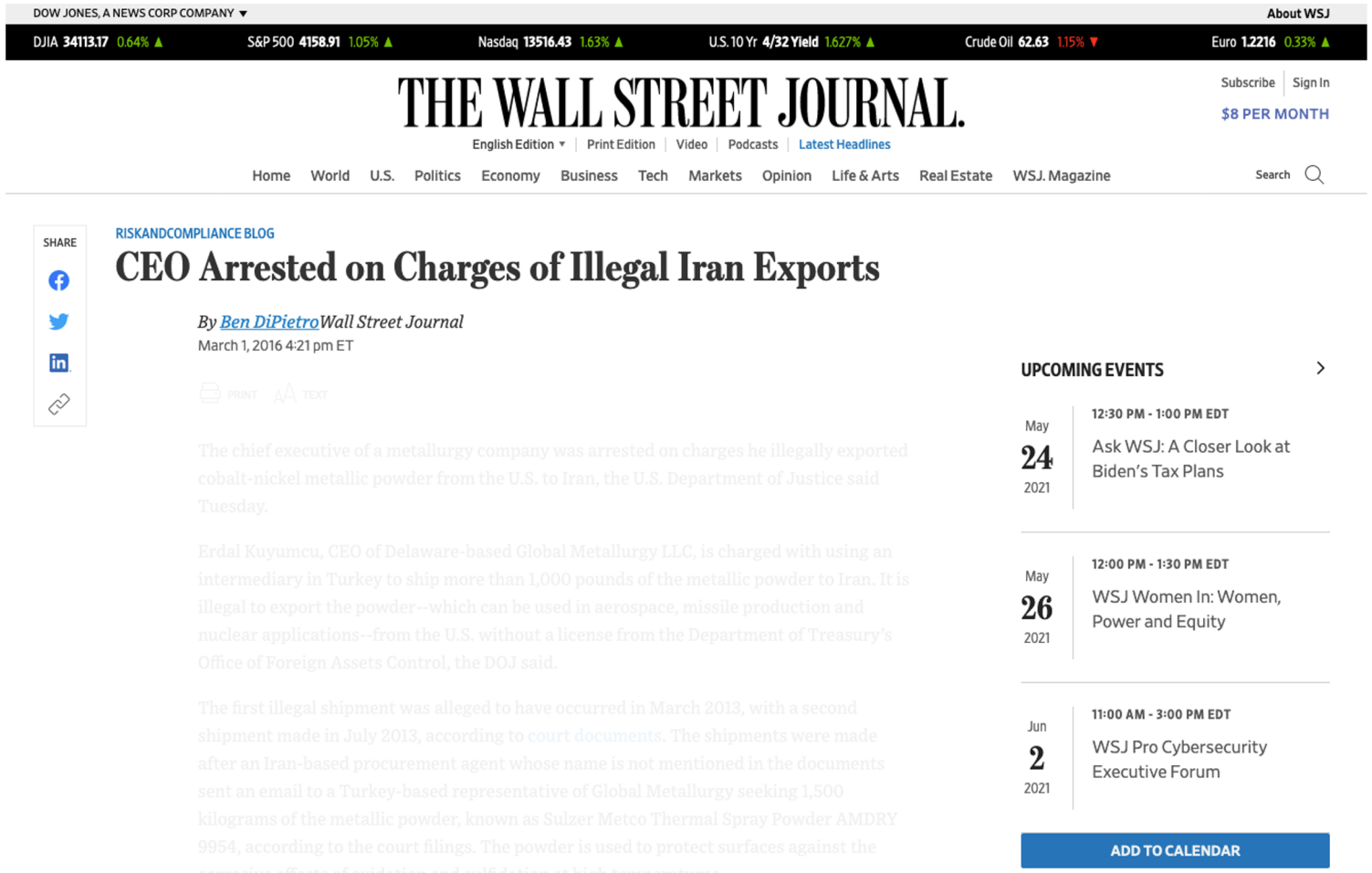
Illicit Chemical Procurement Networks

Metal Powders Case Study

How did the network facilitate the sale?

- The CEO of U.S. company Global Metallurgy LLC was a key perpetrator
- Middlemen at companies in Turkey and Iran were also involved

The Turkish company had initial difficulties acquiring the dual-use goods and in emails used coded language, calling Iran "The Neighbor".



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RISKANDCOMPLIANCE BLOG

CEO Arrested on Charges of Illegal Iran Exports

By Ben DiPietro Wall Street Journal

March 1, 2016 4:21 pm ET

PRINT TEXT

The chief executive of a metallurgy company was arrested on charges he illegally exported cobalt-nickel metallic powder from the U.S. to Iran, the U.S. Department of Justice said Tuesday.

Erdal Kuyumcu, CEO of Delaware-based Global Metallurgy LLC, is charged with using an intermediary in Turkey to ship more than 1,000 pounds of the metallic powder to Iran. It is illegal to export the powder--which can be used in aerospace, missile production and nuclear applications--from the U.S. without a license from the Department of Treasury's Office of Foreign Assets Control, the DOJ said.

The first illegal shipment was alleged to have occurred in March 2013, with a second shipment made in July 2013, according to court documents. The shipments were made after an Iran-based procurement agent whose name is not mentioned in the documents sent an email to a Turkey-based representative of Global Metallurgy seeking 1,500 kilograms of the metallic powder, known as Sulzer Metco Thermal Spray Powder AMDRY 9954, according to the court filings. The powder is used to protect surfaces against the corrosive effects of oxidation and sulfidation at high temperatures.

"As alleged, Erdal Kuyumcu intentionally misrepresented illegal business transactions to make them appear legitimate, thereby threatening national security and violating federal

UPCOMING EVENTS

May 24 2021 — 12:30 PM - 1:00 PM EDT — Ask WSJ: A Closer Look at Biden's Tax Plans

May 26 2021 — 12:00 PM - 1:30 PM EDT — WSJ Women In: Women, Power and Equity

Jun 2 2021 — 11:00 AM - 3:00 PM EDT — WSJ Pro Cybersecurity Executive Forum

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https://www.wsj.com/articles/BL-252B-9579

Illicit Chemical Procurement Networks

Metal Powders Case Study

CEO Arrested on Charges of Illegal Iran Exports

Company A
Ohio

End user?

Global Metallurgy LLC
Delaware

International Bank B
New York

Turkish Representative

"Civilian Purpose"

Iranian Procurement Agent

False End User Company C
Turkey

Steel Company D
Iran

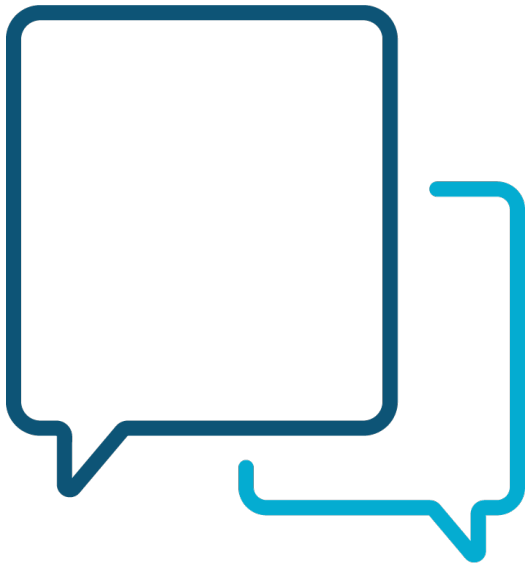
Iranian Entity on OFAC List

Illicit Chemical Procurement Networks

Metal Powders Case Study

How might we disrupt this type of illicit acquisition?

How else might a state proliferator go about acquiring dual-use goods?



Company A
Ohio

Global Metallurgy LLC
Delaware

International Bank B
New York

Turkish Representative

False End User Company C
Turkey

Iranian Procurement Agent

Steel Company D
Iran

Iranian Entity on OFAC List

Chemicals with Identified Security Concerns

What other resources exist?

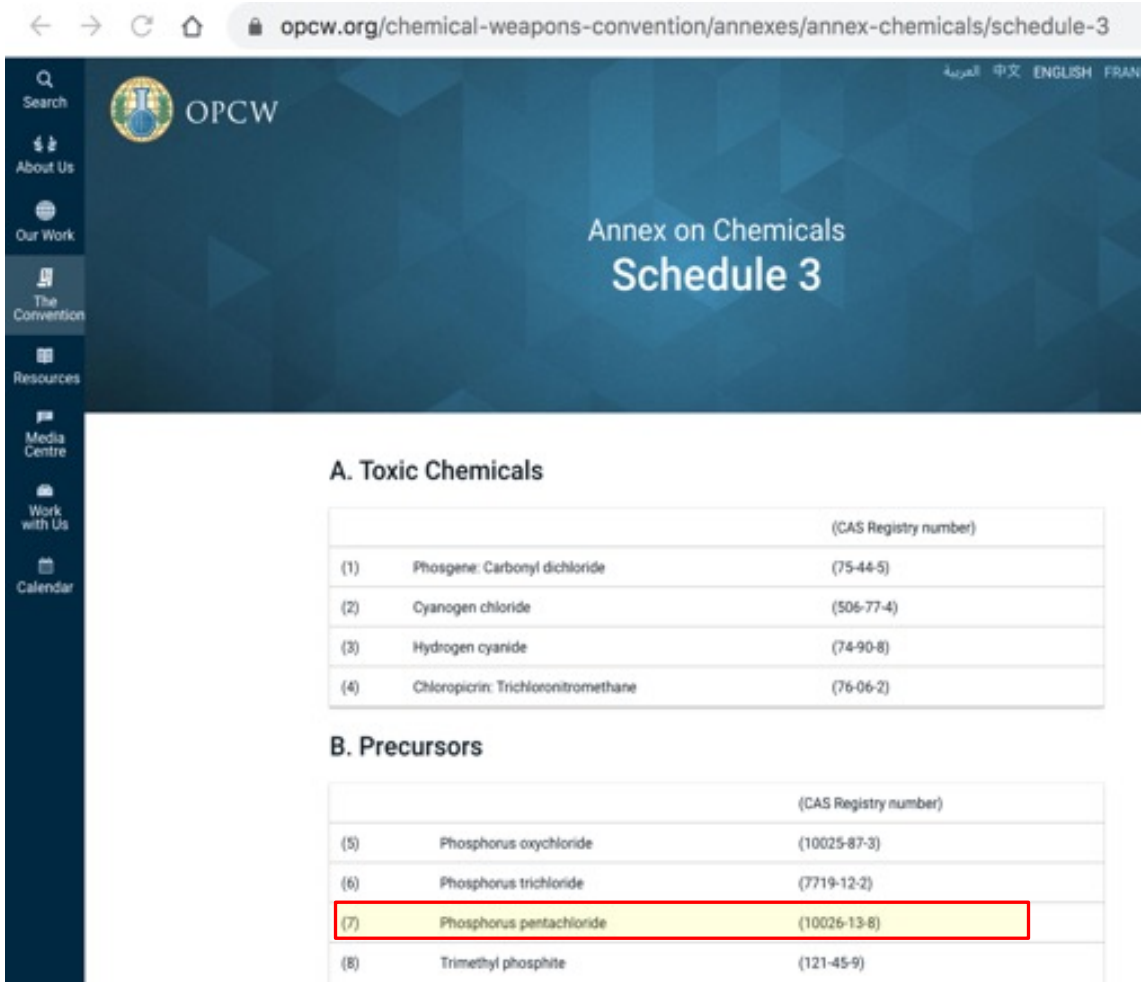
- Lists of chemicals and equipment with security concerns have been published:
  - Chemical weapon agents and their precursors
  - Toxic industrial chemicals
  - Explosives and their precursors
  - Dual-use chemical manufacturing equipment

OPCW

The Australia Group

https://www.opcw.org/chemical-weapons-convention/annexes/annex-chemicals/schedule-1
https://www.dfat.gov.au/publications/minisite/theaustraliagroupnet/site/en/index.html
https://www.cisa.gov/chemical-facility-anti-terrorism-standards
https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32009R0428&from=EN#d1e225-1-1

Chemicals with Identified Security Concerns
CWC: Phosphorus Pentachloride



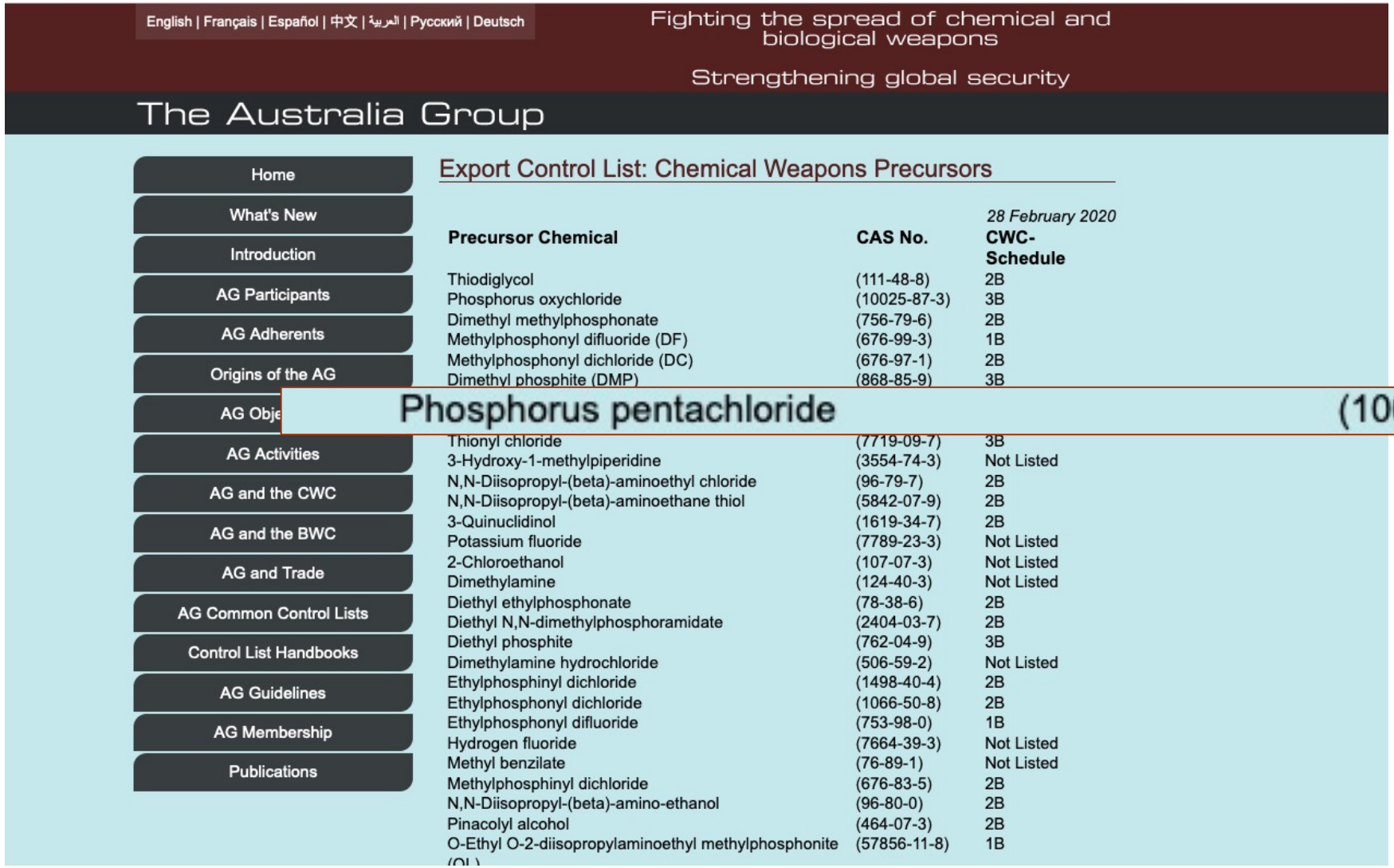
Schedule 3

- Used/stockpiled as a chemical weapon;
- Schedule I or 2 chemical precursor;
- Lethal or incapacitating properties that could enable its use as a chemical weapon

Note: Screenshot taken on 2 May 2022 from: https://www.opcw.org/chemical-weapons-convention/annexes/annex-chemicals/schedule-3

Chemicals with Identified Security Concerns

Australia Group: Phosphorus Pentachloride



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Fighting the spread of chemical and biological weapons

Strengthening global security

The Australia Group

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AG and Trade
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Export Control List: Chemical Weapons Precursors

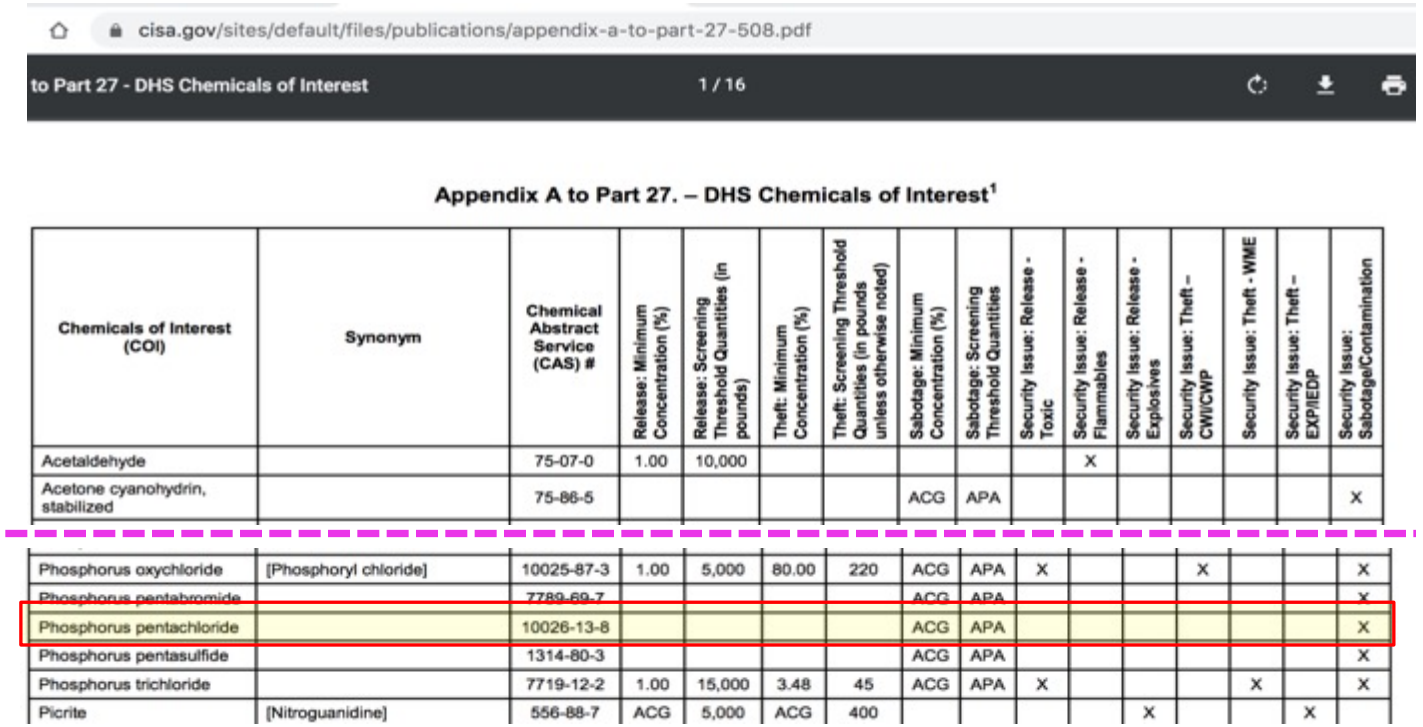
28 February 2020

Precursor Chemical	CAS No.	CWC-Schedule
Thiodiglycol	(111-48-8)	2B
Phosphorus oxychloride	(10025-87-3)	3B
Dimethyl methylphosphonate	(756-79-6)	2B
Methylphosphonyl difluoride (DF)	(676-99-3)	1B
Methylphosphonyl dichloride (DC)	(676-97-1)	2B
Dimethyl phosphite (DMP)	(868-85-9)	3B
Phosphorus pentachloride	**(10026-13-8)**	**3B**
Thionyl chloride	(7719-09-7)	3B
3-Hydroxy-1-methylpiperidine	(3554-74-3)	Not Listed
N,N-Diisopropyl-(beta)-aminoethyl chloride	(96-79-7)	2B
N,N-Diisopropyl-(beta)-aminoethane thiol	(5842-07-9)	2B
3-Quinuclidinol	(1619-34-7)	2B
Potassium fluoride	(7789-23-3)	Not Listed
2-Chloroethanol	(107-07-3)	Not Listed
Dimethylamine	(124-40-3)	Not Listed
Diethyl ethylphosphonate	(78-38-6)	2B
Diethyl N,N-dimethylphosphoramidate	(2404-03-7)	2B
Diethyl phosphite	(762-04-9)	3B
Dimethylamine hydrochloride	(506-59-2)	Not Listed
Ethylphosphinyl dichloride	(1498-40-4)	2B
Ethylphosphonyl dichloride	(1066-50-8)	2B
Ethylphosphonyl difluoride	(753-98-0)	1B
Hydrogen fluoride	(7664-39-3)	Not Listed
Methyl benzilate	(76-89-1)	Not Listed
Methylphosphinyl dichloride	(676-83-5)	2B
N,N-Diisopropyl-(beta)-amino-ethanol	(96-80-0)	2B
Pinacolyl alcohol	(464-07-3)	2B
O-Ethyl O-2-diisopropylaminoethyl methylphosphonite (QL)	(57856-11-8)	1B

Note: Screenshot taken on 2 May 2022 from https://www.dfat.gov.au/publications/minisite/theaustraliagroupnet/site/en/precursors.html

Chemicals with Identified Security Concerns

Chemical Facilities Anti-Terrorism Standards: Phosphorus Pentachloride



cisa.gov/sites/default/files/publications/appendix-a-to-part-27-508.pdf

to Part 27 - DHS Chemicals of Interest 1 / 16

Appendix A to Part 27. – DHS Chemicals of Interest[1]

Chemicals of Interest (COI)	Synonym	Chemical Abstract Service (CAS) #	Release: Minimum Concentration (%)	Release: Screening Threshold Quantities (in pounds)	Theft: Minimum Concentration (%)	Theft: Screening Threshold Quantities (in pounds unless otherwise noted)	Sabotage: Minimum Concentration (%)	Sabotage: Screening Threshold Quantities	Security Issue: Release - Toxic	Security Issue: Release - Flammables	Security Issue: Release - Explosives	Security Issue: Theft – CWI/CWP	Security Issue: Theft - WME	Security Issue: Theft – EXP/IEDP	Security Issue: Sabotage/Contamination
Acetaldehyde		75-07-0	1.00	10,000						X					
Acetone cyanohydrin, stabilized		75-86-5					ACG	APA							X
Phosphorus oxychloride	[Phosphoryl chloride]	10025-87-3	1.00	5,000	80.00	220	ACG	APA	X			X			X
Phosphorus pentabromide		7789-69-7					ACG	APA							X
Phosphorus pentachloride		10026-13-8					ACG	APA							X
Phosphorus pentasulfide		1314-80-3					ACG	APA							X
Phosphorus trichloride		7719-12-2	1.00	15,000	3.48	45	ACG	APA	X				X		X
Picrite	[Nitroguanidine]	556-88-7	ACG	5,000	ACG	400					X			X	

Note: this is an excerpt of the CFATS list. The full list is available: https://www.cisa.gov/appendix-chemicals-interest (accessed 2 May, 2022)

Chemicals with Identified Security Concerns

E.U. Council Regulation 428/2009: Phosphorus Pentachloride

N.B.: SEE ALSO MILITARY GOODS CONTROLS AND 1C450.

1. Thiodiglycol (111-48-8);
2. Phosphorus oxychloride (10025-87-3);
3. Dimethyl methylphosphonate (756-79-6);
4. **SEE MILITARY GOODS CONTROLS FOR Methyl phosphonyl difluoride (676-99-3**
5. Methyl phosphonyl dichloride (676-97-1);
6. Dimethyl phosphite (DMP) (868-85-9);

35. Ethyl phosphinyl difluoride (430-78-4);
36. Methyl phosphinyl difluoride (753-59-3);
37. 3-Quinuclidone (3731-38-2);
38. Phosphorus pentachloride (10026-13-8);
39. Pinacolone (75-97-8);
40. Potassium cyanide (151-50-8);
41. Potassium bifluoride (7789-29-9);

Screenshot taken on May 2, 2022; https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32009R0428&from=EN#d1e32-12-1

Chemical Security Risk Assessment

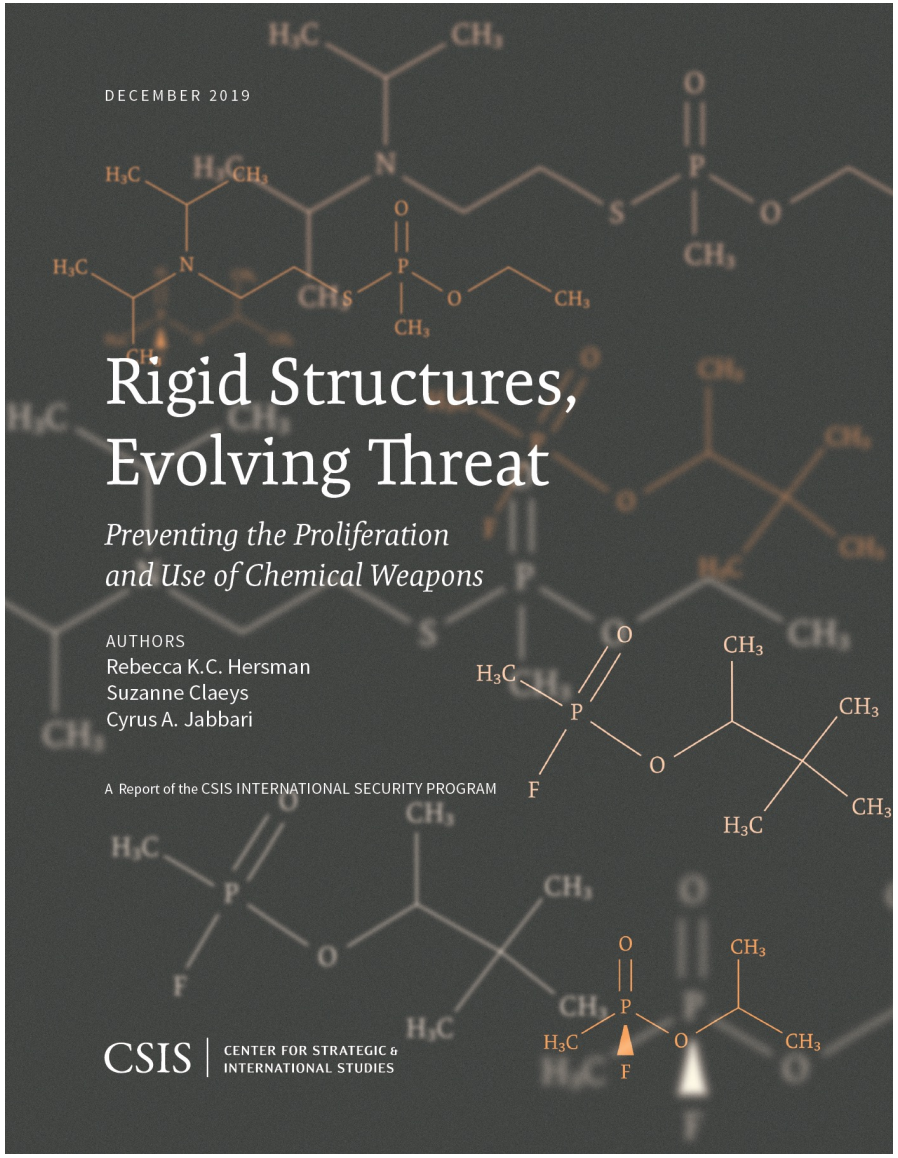
RISK ASESSMENT

- What can go wrong?
- How likely is it?
- What are the consequences?

1. WHAT DO WE HAVE?
2. WHO WOULD WANT IT?
3. SHOULD WE BE CONCERNED?
4. IS THIS ACCEPTABLE?
5. WHAT DO WE DO ABOUT IT?

Systematically prioritize risks so that resources are used most effectively for improving or adding controls

Current Challenges to Chemical Security



- Small, one off uses of CW
- Enforcement and accountability
- New CW acquisition trends
- New and emerging threats
- Disinformation
- Open-source investigation and verification
- **Lack of knowledge or interest in CW**

Center for Strategic & International Studies (Dec. 2019) Hersman, Claeys and Jabbari

Are Social Norms Around Chemical Weapons Eroding?

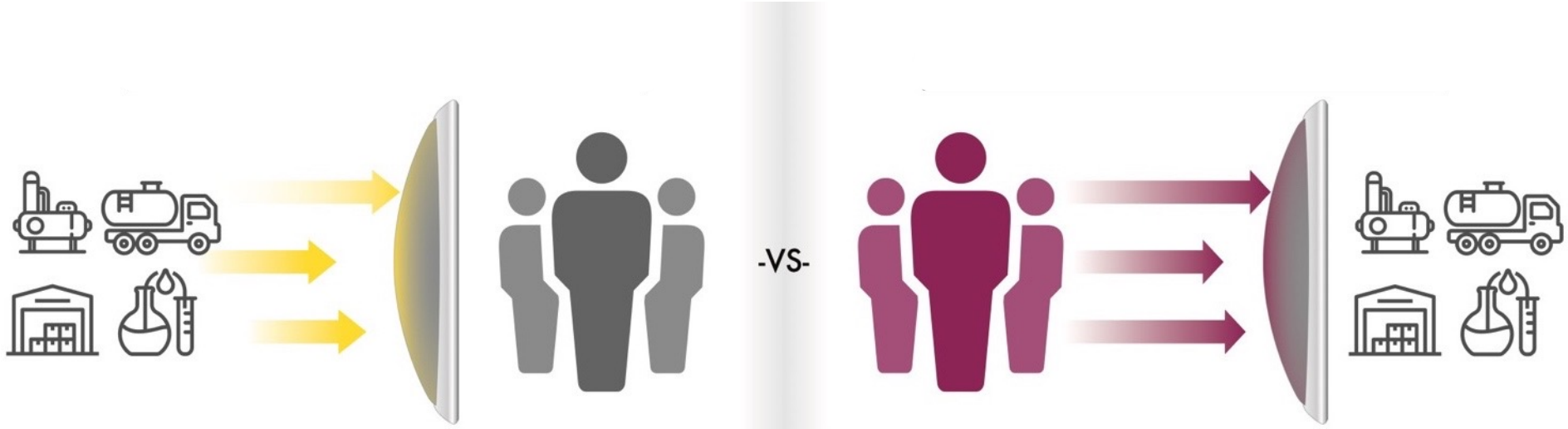
Pessimistic View: CWs have been used multiple times in the last 5-10 years and their use and sharing of techniques may increase.

Optimistic View: International efforts have helped to prevent the widespread use of CWs since WWI and these efforts will continue towards the eradication of CWs.

Realistic View: The social norms around the use and production of chemical weapons are eroding. International efforts have made CWs and CW precursors more difficult to obtain. These efforts will drive non-state actors towards use of more readily available chemicals and unconventional CWs.

Nature **556**, 293-295 (2018)

Thank you for your attention



What questions do you have?