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Mintrabajo

# MINING HEALTH AND SAFETY IN THE UNITED STATES: MANAGEMENT SYSTEMS, INJURY REPORTING AND DATA ANALYSIS

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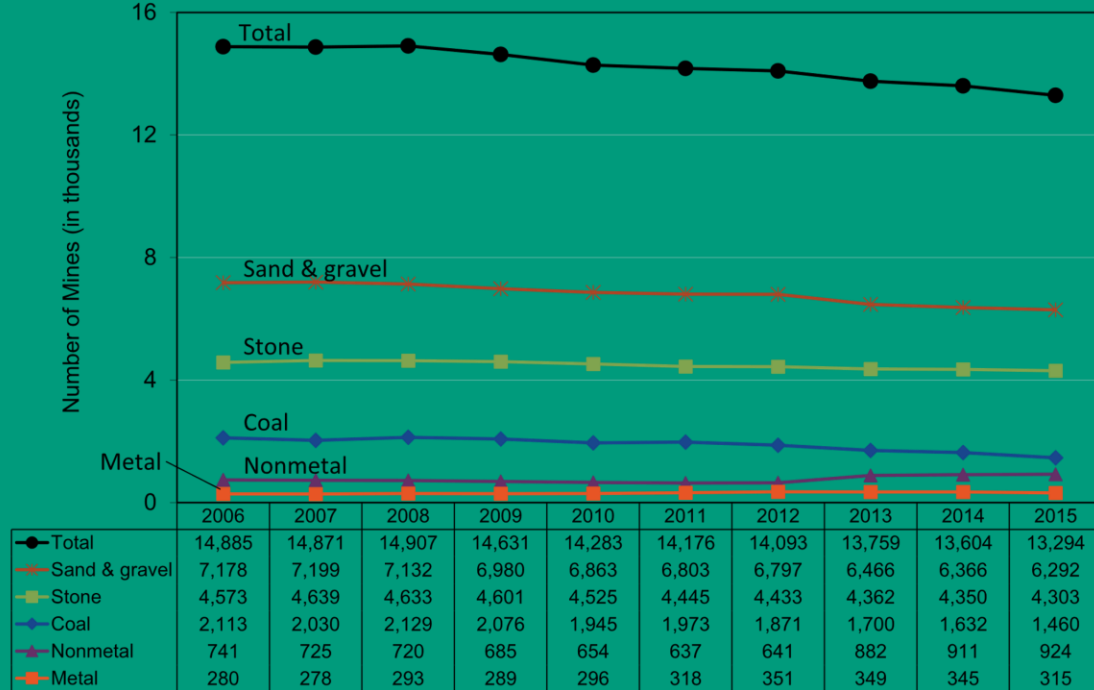
THE DEPARTMENT OF MINING & MINERALS ENGINEERING  
AT VIRGINIA TECH





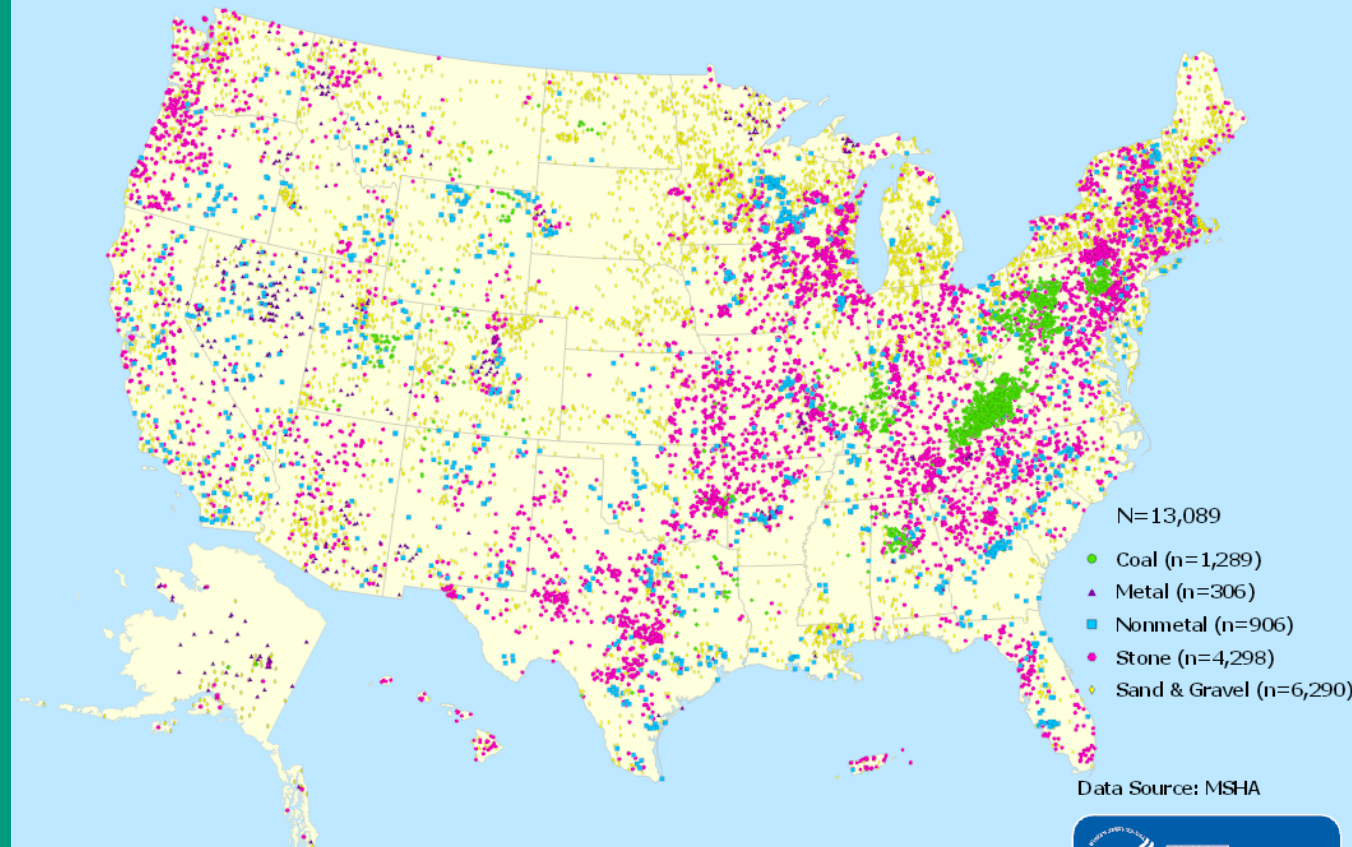
# CURRENT MINES IN THE U.S.

### Number of active mines by commodity and year, 2006-2015



NOTE: Active mines are those mines that reported any employee hours during the year. Data source: MSHA

## Active Mining Operations by Commodity, 2016



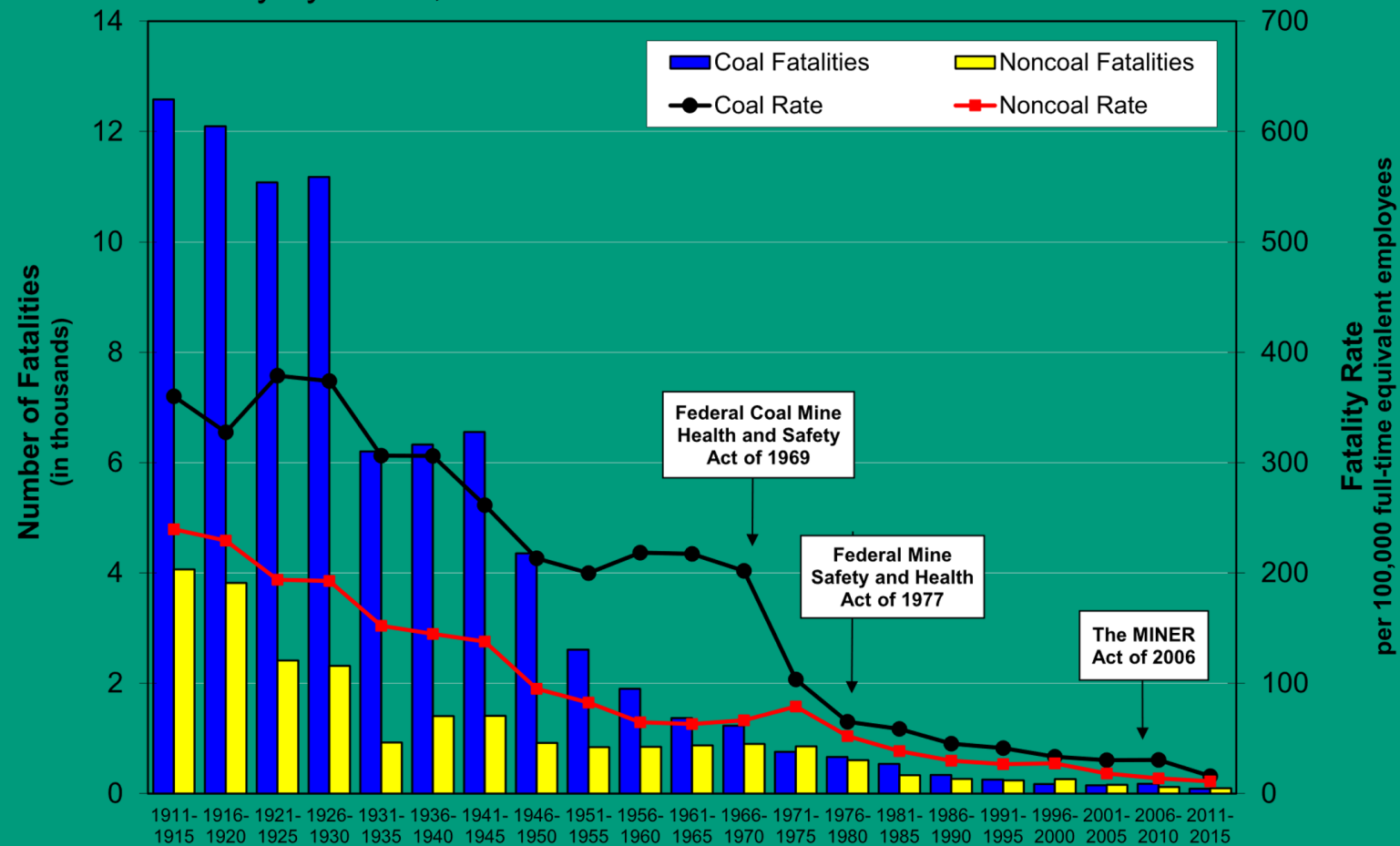
Notes: U.S. Virgin Islands are not shown. Mining operations that reported any mine operator employment during the year are spotted randomly within counties. Mines where only contractors were working did not show employment and are not displayed.





# HISTORICAL MINING FATALITIES IN U.S.

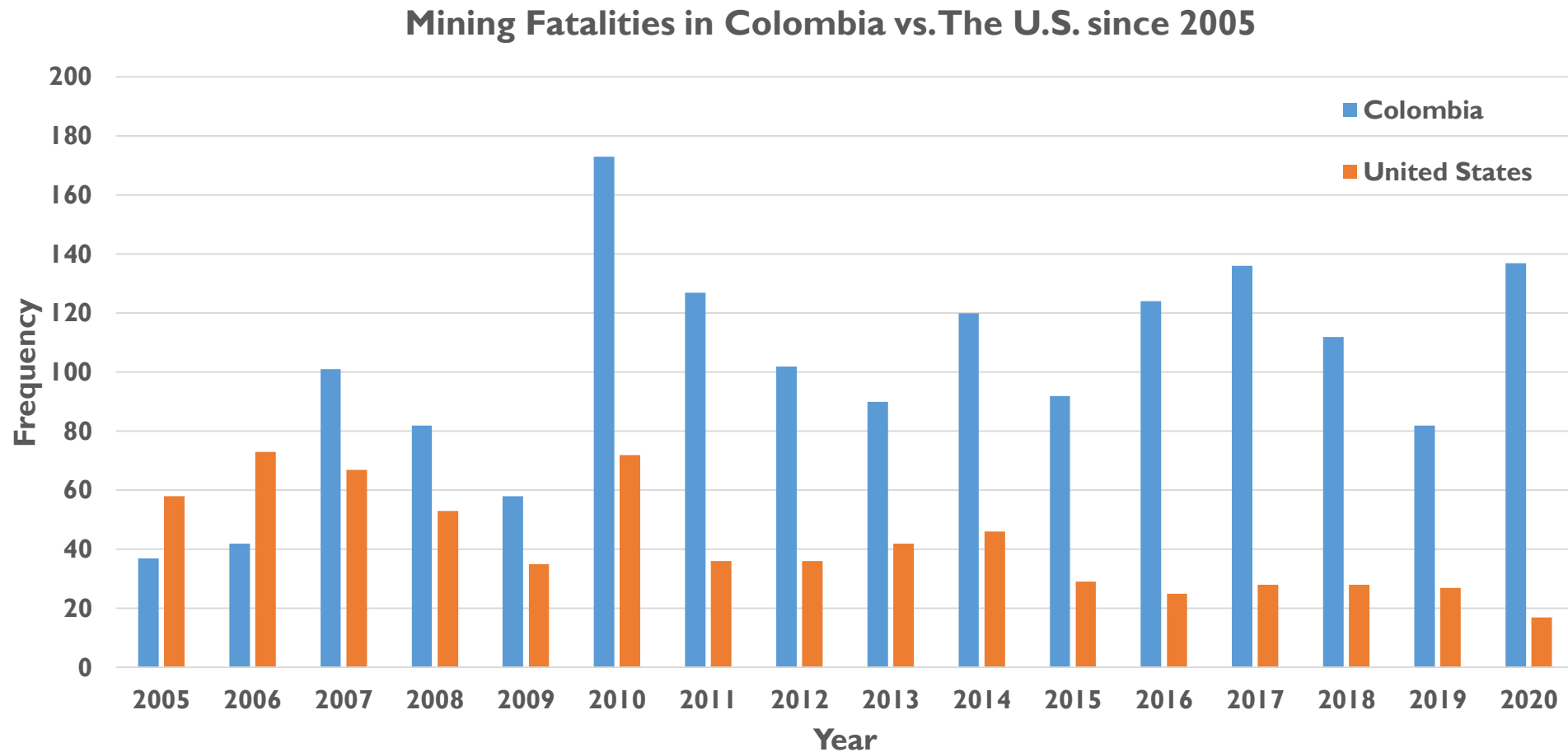
Number of fatalities and fatality rates (5-year aggregates) in the mining industry by sector, 1911-2015



- Federal Mine Safety Act of 1977 (“The Act”)
  - <https://arlweb.msha.gov/REGS/ACT/ACTTC.htm>
- MINER Act of 2006
  - <https://arlweb.msha.gov/MinerAct/MinerActSingleSource.asp>
- Code of Federal Regulations
  - Mining regulations change yearly
  - <https://arlweb.msha.gov/regs/30cfr/>



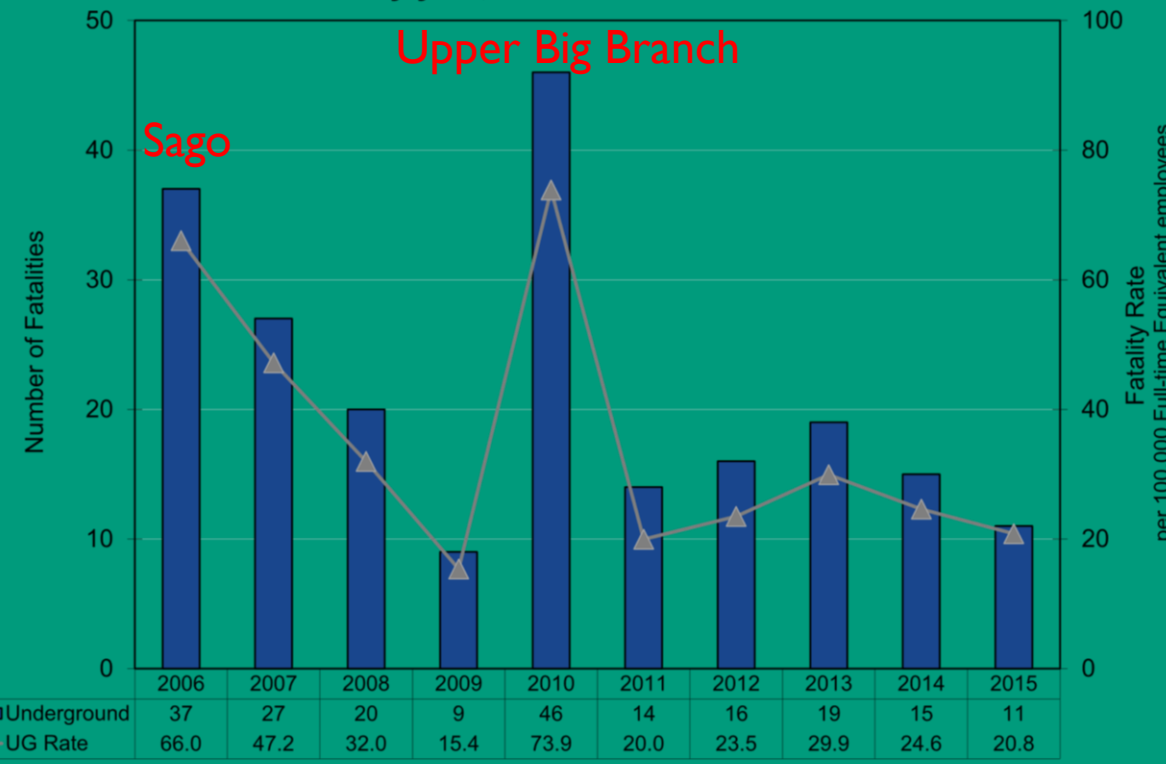
# MINING FATALITIES IN COLOMBIA (AGENCIA NACIONAL DE MINERÍA) VERSUS THE U.S. SINCE 2005 (MSHA)



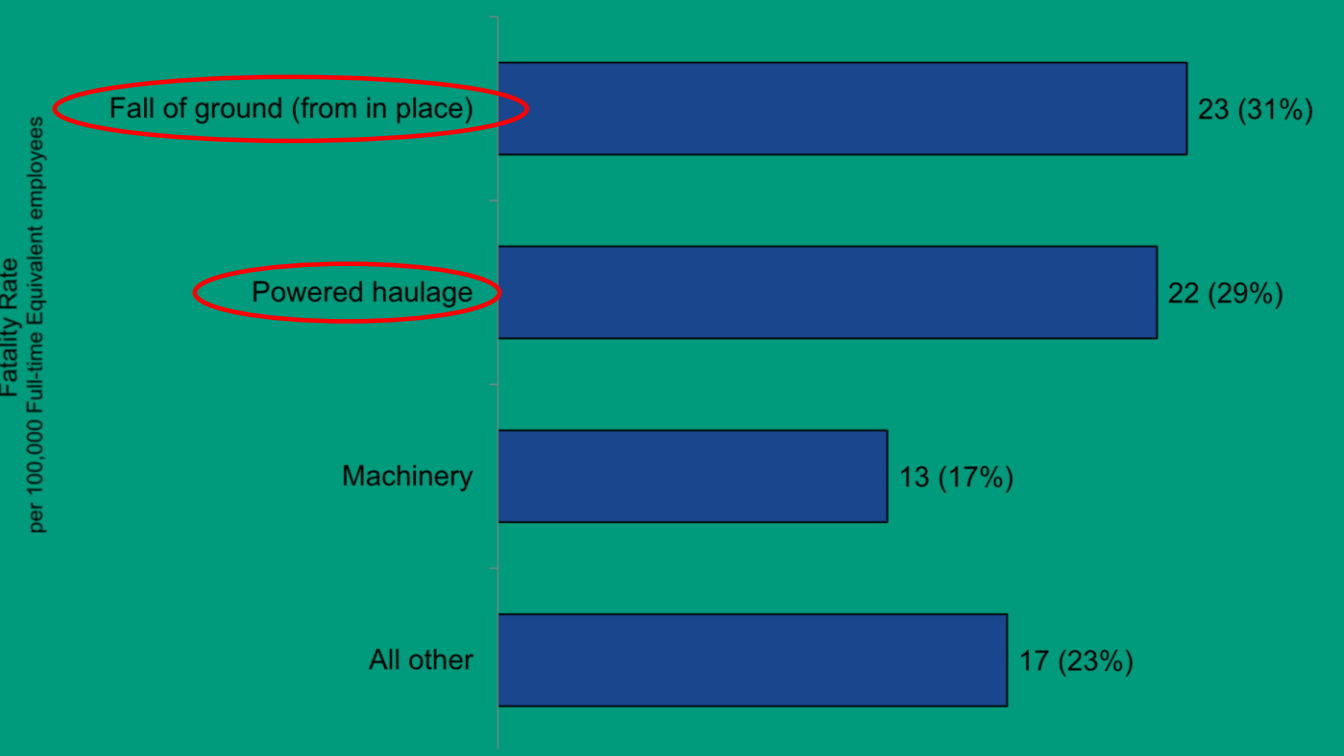


# FATALITY TRENDS IN UNDERGROUND MINES IN U.S.

Number and rate of occupational mining fatalities at underground work locations by year, 2006-2015



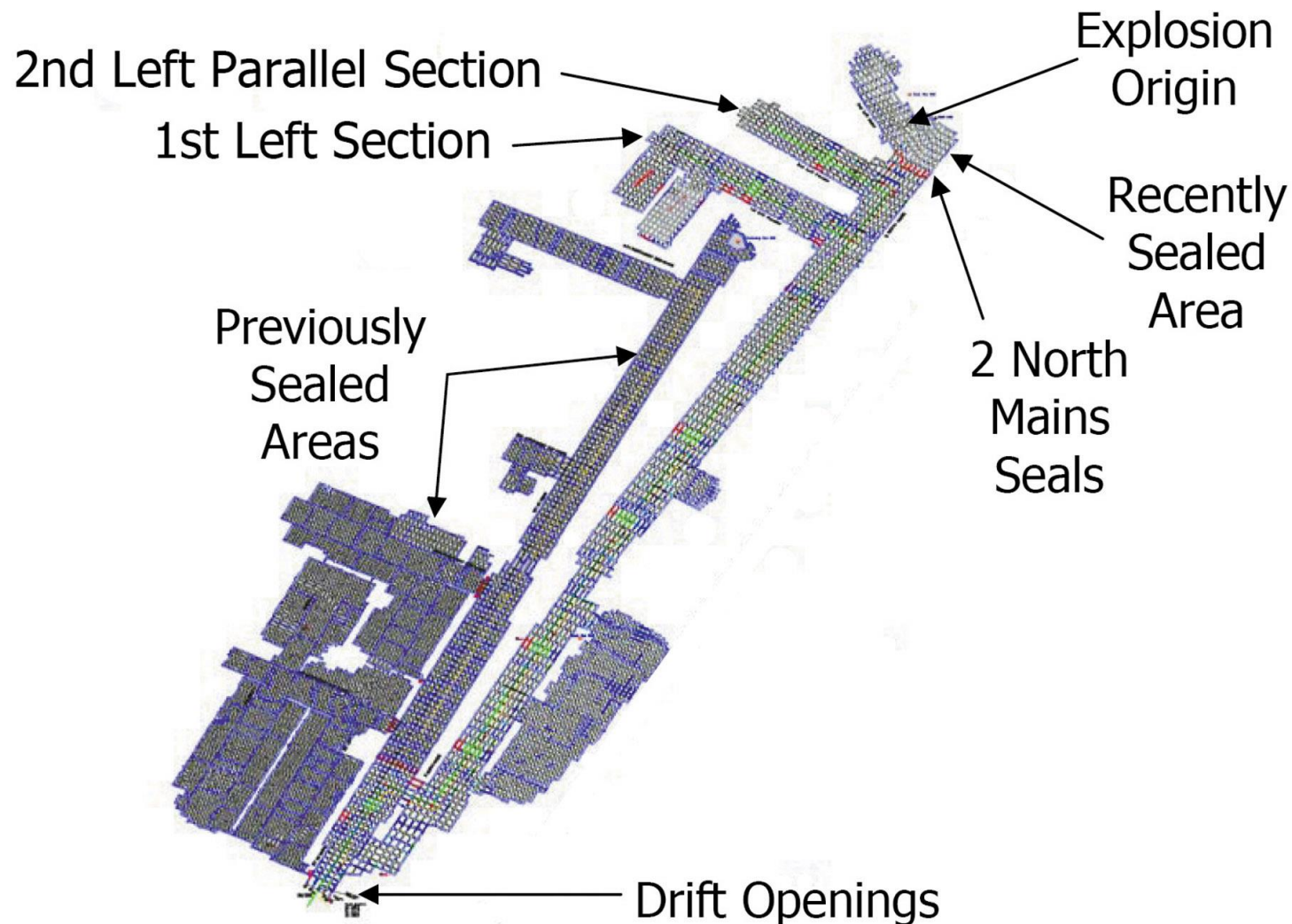
Number and percentage of occupational fatalities by accident class Underground mining locations, 2011-2015 (N=75)





## SAGO MINE DISASTER - 2006

- 12 miners killed in blast in sealed area likely caused by lightning strike
- Miners killed by CO (carbon monoxide poisoning), not from the blast
- Could have escaped, but did not have the training or equipment to do so
- Led to MINER Act of 2006







# MINER ACT OF 2006 – AFTER SAGO MINE DISASTER

- MINER Act:
  - <https://arlweb.msha.gov/MinerAct/MinerActSingleSource.asp>
  - Increase the availability of emergency breathing devices and provide improved training on the use of the devices,
  - Improve emergency evacuation and drill training
    - Conduct MERDs at mines
  - Install lifelines for emergency evacuation
  - Two-Way Communications and Electronic Tracking Required
  - Seal strength, design, construction, maintenance and repair of seals
  - Requirement of Refuge Alternatives at face and every 30 minutes outby

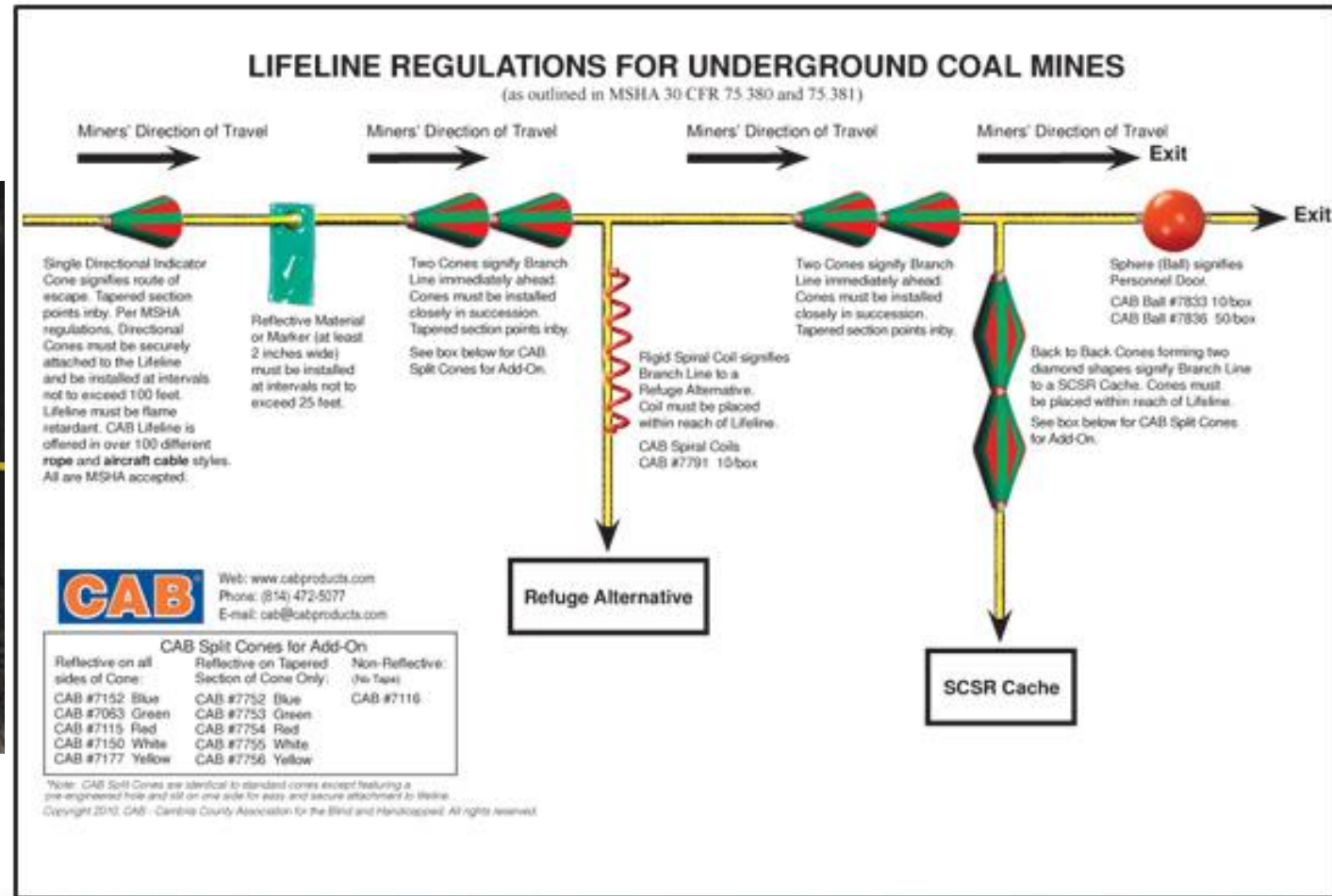




# MINER ACT OF 2006 – AFTER SAGO MINE DISASTER



© 2014, Cambria County Association for the Blind and Handicapped.







## UPPER BIG BRANCH MINE DISASTER - 2010

- 29 miners killed in methane/coal dust explosion in 2010 at Massey Energy Mine
- <https://arlweb.msha.gov/Fatals/2010/UBB/PerformanceCoalUBB.asp>
- Led to Pattern of Violations (POV) Rule
- Led to more stringent enforcement and penalties for failure to Rock Dust as well as maintain equipment (e.g. water sprays and methane monitors)
- Led to more pre-shift, on-shift and weekly examinations





# UPPER BIG BRANCH MINE DISASTER

- Alpha Natural Resources bought Massey and agreed to pay \$209 million fine:
  - \$80 million to boost safety in their mines
  - \$48 million fund for mining-safety and health research.
  - \$34.8 million in fines
- Alpha Foundation for Improving Mine Safety and Health
  - <https://www.alpha-foundation.org/>
- Alpha Running Right Leadership Academy
  - <http://www.alphanr.com/safety/Pages/RRLA.aspx>

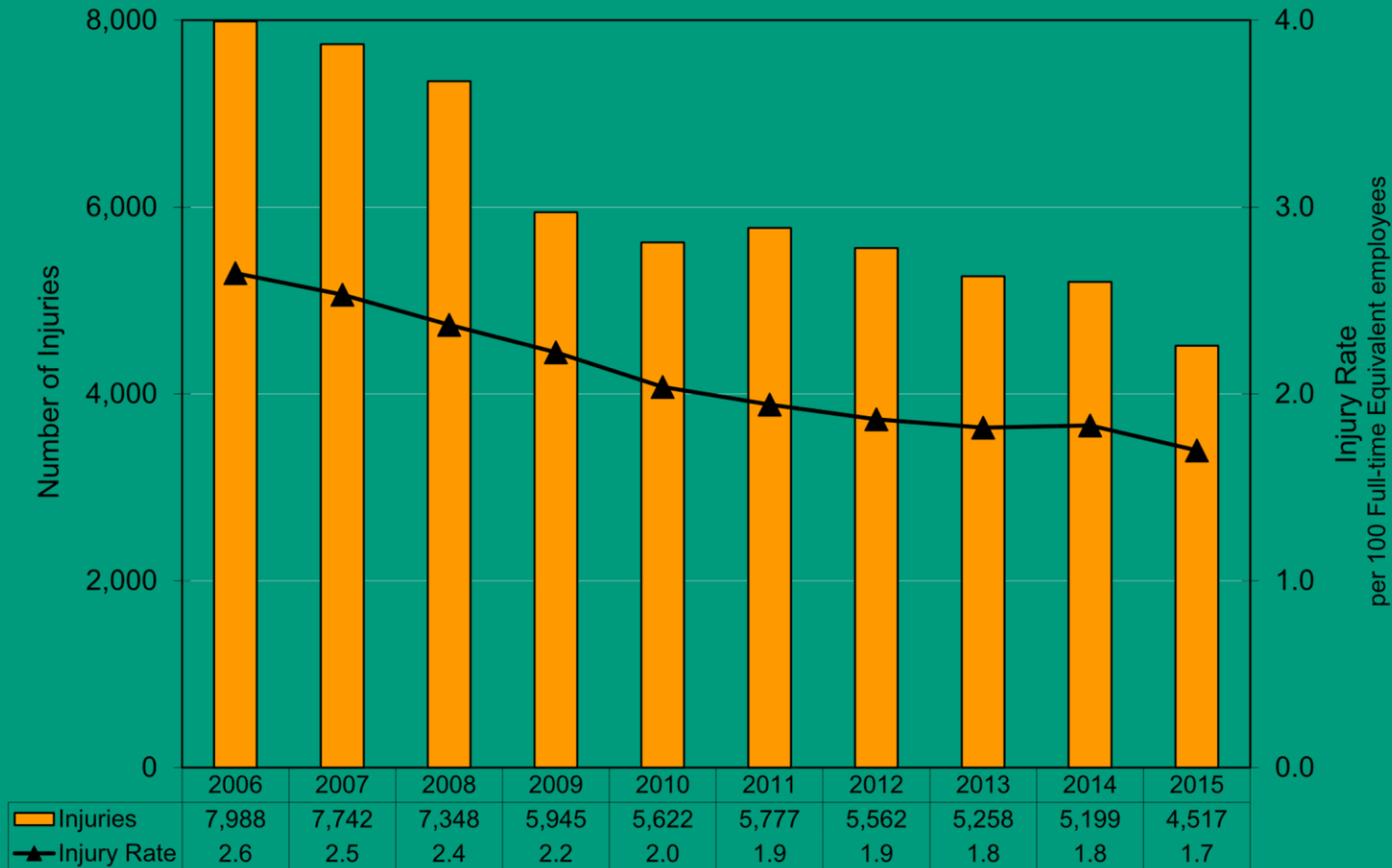


Source: NPR; <https://www.npr.org/sections/thetwo-way/2011/01/19/133055616/feds-illustrate-likely-cause-of-mine-blast>



# NOT JUST FATALITIES – NON-FATAL DAYS LOST INJURIES (NFDL)

Number and rate of mining nonfatal lost-time injuries by year, 2006-2015



- **FATAL** (work-related injuries resulting in death to employees on active mine property);
- **NONFATAL, DAYS LOST (NFDL)** cases (occupational injuries that result in loss of one or more days from the employee's scheduled work, or days of limited or restricted activity while at work);
- **NO DAYS LOST (NDL)** cases (occurrences requiring only medical treatment - beyond first aid). "Incidence rates" are the number of injuries in a category times 200,000 divided by the number of employee-hours worked.



## MSHA REPORTABLE ACCIDENT

1. A death of an individual at a mine;
2. An injury to an individual at a mine which has a reasonable potential to cause death;
3. An entrapment of an individual for more than thirty minutes;
4. An unplanned inundation of a mine by a liquid or gas;
5. An unplanned ignition or explosion of gas or dust;
6. An unplanned mine fire not extinguished within 30 minutes of discovery;
7. An unplanned ignition or explosion of a blasting agent or an explosive;
8. An unplanned roof or rib fall at or above the anchorage zone or that impairs ventilation or impedes passage;
9. A coal or rock outburst that causes withdrawal of miners or which disrupts regular mining activity for more than one hour;



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# MSHA DATA RETRIEVAL SYSTEM

- <https://arlweb.msha.gov/drs/drshome.htm>
- Information on Inspections
  - Citations, Orders and Fines
- Information on Accidents
  - MSHA Requires Form 7000-I for an accident
    - <https://arlweb.msha.gov/forms/7000IINB.HTM>
    - Accident Code; Steps Taken to Prevent Recurrence; Where; When; Description; Equipment; Experience
  - Database of 100,000+ accidents since 1984
  - <https://www.cdc.gov/niosh/mining/data/default.html>
  - Key criteria: Days Lost from work, Miner Experience
- Information on Dust Sampling in Coal Mines

**U.S. Department of Labor**  
Mine Safety and Health Administration

Approved For Use Through 07/31/2014 OMB Number 1219-0007

**Mine Accident, Injury and Illness Report**

• Section A - Identification D

MSHA ID Number Contractor ID Report Category  Metal/Nonmetal Mining  Coal Mining  Check here if report pertains to contractor

Mine Name Company Name

• Section B - Complete for Each Reportable Accident Immediately Reported to MSHA

Accident Code (circle applicable code - see instructions)  01 - Death  02 - Serious Injury  03 - Entrapment  
 04 - Inundation  05 - Gas or Dust Ignition  06 - Mine Fire  07 - Explosives  08 - Roof Fall  
 09 - Outburst  10 - Impounding Dam  11 - Hoisting  12 - Offsite Injury

2. Name of Investigator 3. Date Investigation Started 4. Steps Taken to Prevent Recurrence of Accident

Month Day Year

• Section C - Complete for Each Reportable Accident, Injury or Illness

5. Circle the Codes Which Best Describe Where Accident/Injury/Illness Occurred (see instructions)

(a) Surface Location:  02 Surface at Underground Mine  30 Mill, Preparation Plant, etc.  03 Strip/Open Pit Mine  04 Surface Auger Operation  
 05 Cull Bank/Refuse Pile  06 Dredge Mining  12 Other Surface Mining  17 Independent Shops (with own MSHA ID)  99 Office Facilities

(b) Underground Location:  01 Vertical Shaft  02 Slope/Inclined Shaft  03 Face  04 Intersection  05 Underground Shop/Office  06 Other

(c) Underground Mining Method:  01 Longwall  02 Shortwall  03 Conventional Stopping  05 Continuous Mining  06 Hand  07 Caving  08 Other

6. Date of Accident 7. Time of Accident .am .pm 8. Time Shift Started .am .pm

Month Day Year

9. Describe Fully the Conditions Contributing to the Accident/Injury/Illness, and Quantify the Damage or Impairment

10. Equipment Involved

Equipment Involved	Type	Manufacturer	Model Number

11. Name of Witness to Accident/Injury/Illness 12. Number of Reportable Injuries or Illnesses Resulting from This Occurrence

13. Name of Injured/Ill Employee 14. Sex  Male  Female 15. Date of Birth Month Day Year

16. Last Four Digits of Social Security Number 17. Regular job Title 18. Check if this injury/illness resulted in death.  19. Check if injury/illness resulted in permanent disability (include amputation, loss of use, & permanent total disability).

20. What Directly Inflicted Injury or Illness? 21. Nature of Injury or Illness

22. Part of Body Injured or Affected 23. Occupational illness (circle applicable code - see instructions)  21 Occupational Skin Diseases  
 22 Dust Diseases of the Lungs  23 Respiratory Conditions (toxic agents)  24 Poisoning (toxic materials)  
 25 Disorders (physical agents)  26 Disorders (repeated trauma)  29 Other

Employee's Work Activity When Injury or Illness Occurred	Experience	Years	Weeks
25. Experience in This Job Title			
26. Experience at This Mine			
27. Total Mining Experience			

• Section D - Return to Duty Information

28. Permanently Transferred or Terminated (if checked, complete items 29, 30, & 31)  29. Date Returned to Regular Job at Full Capacity (or item 28) Month Day Year 30. Number of Days Away from Work (if none enter 0) 31. Number of Days Restricted Work Activity (if none, enter 0)

Person Completing Form (name) Title

Date This Report Prepared (month, Day, year) Area Code and Telephone Number

MSHA Form 7000-1, Mar. 03 (revised)

**Reset Form**

**For Official Use Only**

Degree

Accident Type

Accident Class

Scheduled Charge

Keyword





# MSHA DATA RETRIEVAL SYSTEM

■ <https://arlweb.msha.gov/drs/drshome.htm>

- Mine Name = Buchanan Mine; More Info
- Overview, Get Report
- Accidents
- Violations
- Dust Samples
  - Inspectors
  - Company
  - Quartz

We are updating the Inspector Sampling information on a daily basis. Please remember that we gather this information from other systems and there may be some lag time.

### MSHA Inspector Dust Sample Results

The current operator **Buchanan Minerals, LLC** has been the operator since **3/31/2016**

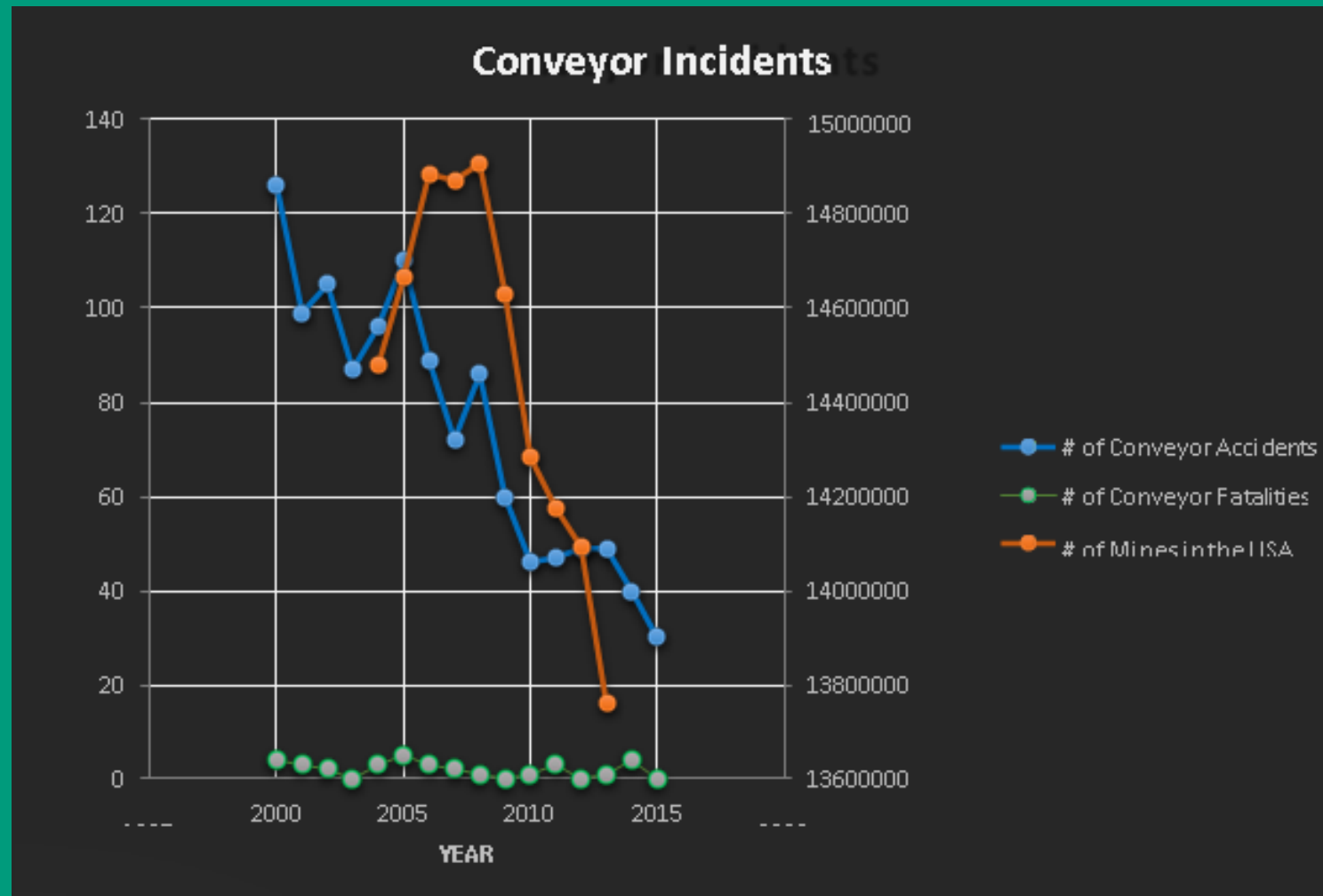
Codes		
Smp_Type	Job Codes	Void Codes
	0xx   1xx   2xx   3xx   4xx   5xx	

Concentrations greater than 1.5 mg (2.0 mg for samples prior to 08/01/2016) are shown in Red

Date	Cass. No.	Entity No.	Job Cd	Init. Wgt.	Final Wgt.	Conc'n	Smp Type	Smp Time	Tons Prod.	Void Cd
8/25/2019	58275167	8500	149	497.97	498.06	0.131	5	483	0	
8/21/2019	58275185	0030	002	498.14	498.41	0.366	2	493	247	
8/21/2019	58275137	9030	014	499.40	499.68	0.389	2	493	247	
8/21/2019	58275092	0030	036	497.85	498.26	0.570	1	493	247	
8/21/2019	58275138	0031	050	498.11	498.43	0.439	2	493	247	
8/21/2019	58275196	0030	054	497.71	498.21	0.698	2	493	247	
8/21/2019	58275101	8040	Unkwn	499.31	499.60	0.387	3	493	247	
8/21/2019	58275106	0030	Unkwn	502.02	502.13	0.142	7	493	247	
8/18/2019	58275100	0120	002	500.02	500.14	0.175	2	437	146	IWS
8/18/2019	58275109	9120	014	496.11	496.35	0.366	2	437	146	IWS
8/18/2019	58275150	0120	036	498.70	498.91	0.315	1	437	146	IWS
8/18/2019	58275120	0121	050	502.96	503.12	0.238	2	437	146	IWS
8/18/2019	58275182	0120	054	495.90	496.17	0.408	2	437	146	IWS
8/18/2019	58275143	0120	Unkwn	500.12	500.26	0.193	7	473	146	IWS
8/18/2019	58275190	8119	Unkwn	495.13	495.28	0.204	3	473	146	IWS
8/14/2019	58275118	0150	002	495.47	495.66	0.255	2	511	262	
8/14/2019	58275180	9150	014	502.72	503.01	0.386	2	511	262	
8/14/2019	58275168	0150	036	493.68	493.96	0.382	1	511	262	
8/14/2019	58275157	0151	050	498.77	499.05	0.388	2	511	262	
8/14/2019	58275110	0150	054	495.46	495.80	0.464	2	511	262	
8/14/2019	58275126	0150	Unkwn	498.53	498.69	0.217	7	511	262	
8/14/2019	58275128	8150	Unkwn	496.14	496.38	0.322	3	511	262	
8/11/2019	58203176	8500	149	499.77	500.06	0.420	5	491	0	
7/30/2019	58202990	0070	002	506.04	506.25	0.314	2	491	376	
7/30/2019	58203195	9070	014	508.25	508.40	0.213	2	491	376	
7/30/2019	58203184	0070	036	504.84	505.39	0.777	1	491	376	
7/30/2019	58203172	0071	050	492.95	493.11	0.244	2	491	376	
7/30/2019	58203171	0070	054	497.54	497.75	0.304	2	491	376	
7/30/2019	58203130	0070	Unkwn	506.93	507.05	0.175	7	491	0	
7/30/2019	58203257	8070	Unkwn	503.91	504.14	0.326	3	491	0	
7/29/2019	58203099	0040	002	501.64	501.81	0.268	2	483	240	



# CONVEYOR BELT ACCIDENTS





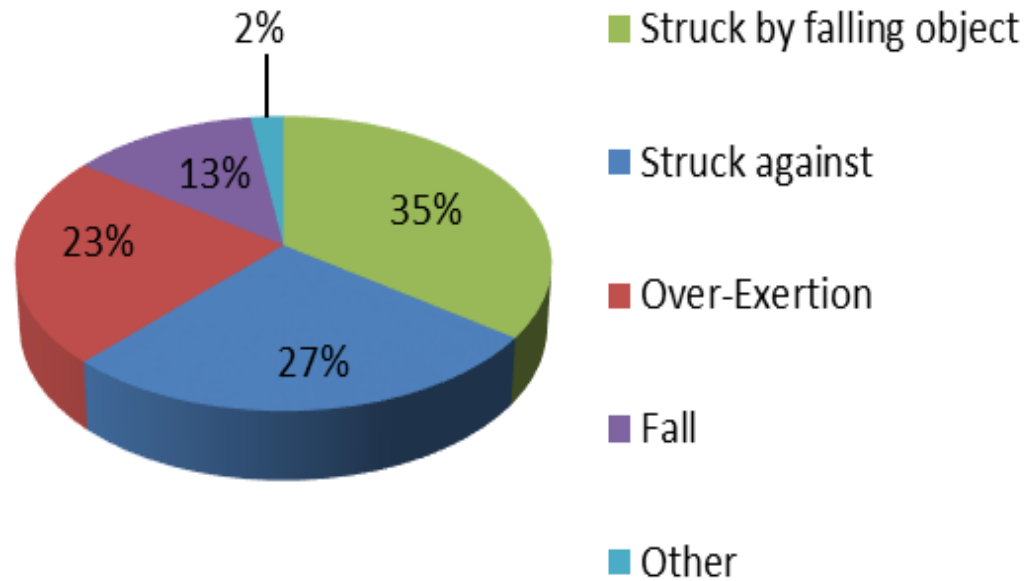
## SCALING IN UNDERGROUND LIMESTONE MINES

- Removal of loose rock from roof and ribs.
  - Manual: scaling bar
  - Mechanical: Hydraulic or pneumatic
- 2003 NIOSH study found half of all ground-fall injuries were scaling related
- 2000-2015: 176 scaling incidents across 48 mines

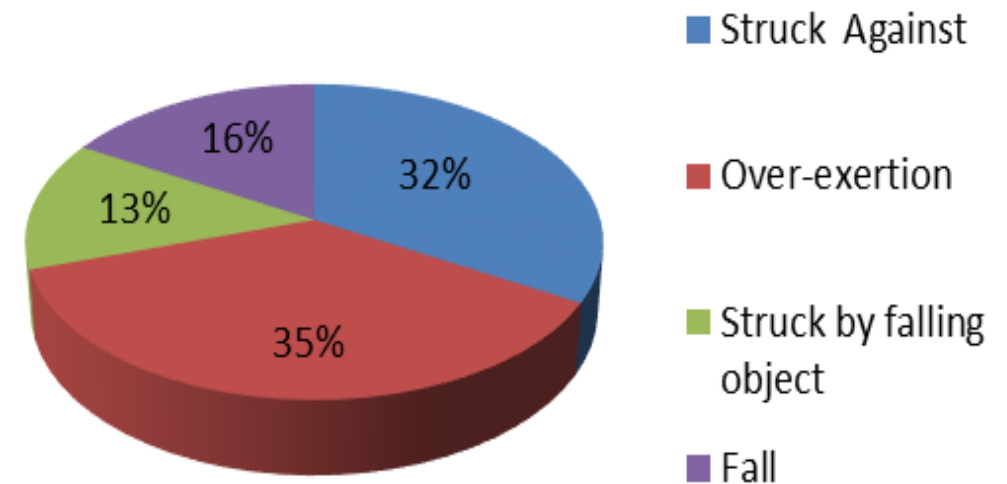


# SCALING INJURIES

## Manual Scaling Injury Type



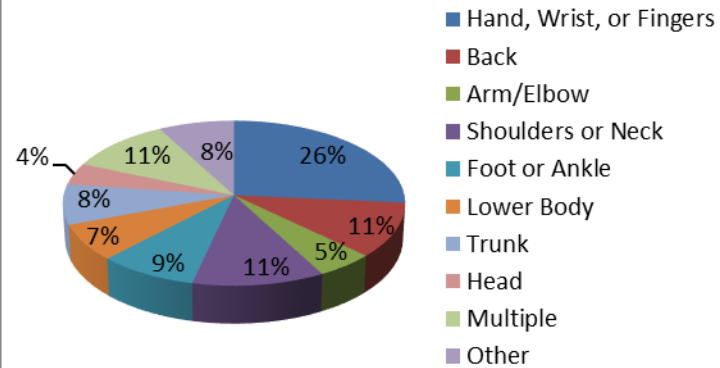
## Mechanical Scaling Injury Type



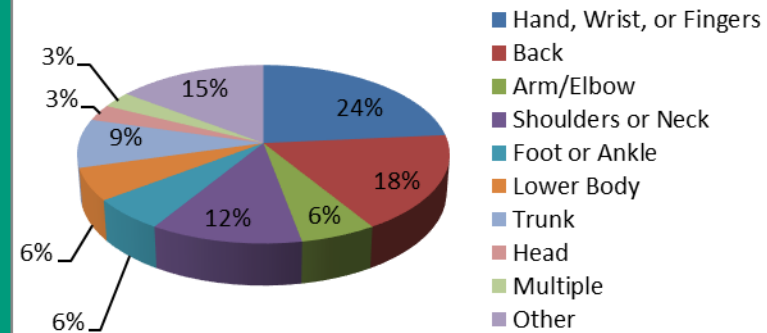


# INJURIES BY BODY PART

### Manual Injury By Body Part



### Mechanical Injury By Body Part

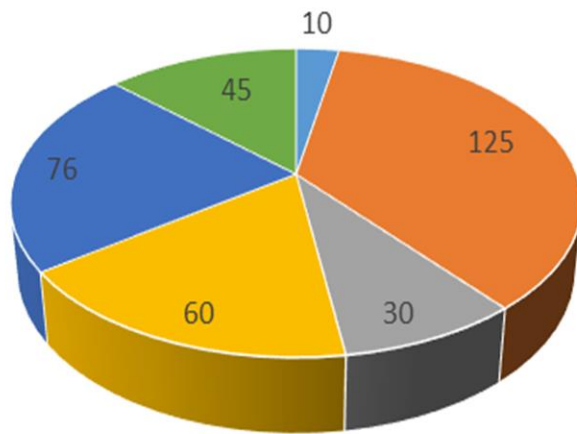






# SLIPS, TRIPS, AND FALLS AT AN AGGREGATE COMPANY SITES

Activity Causing Slip or Fall



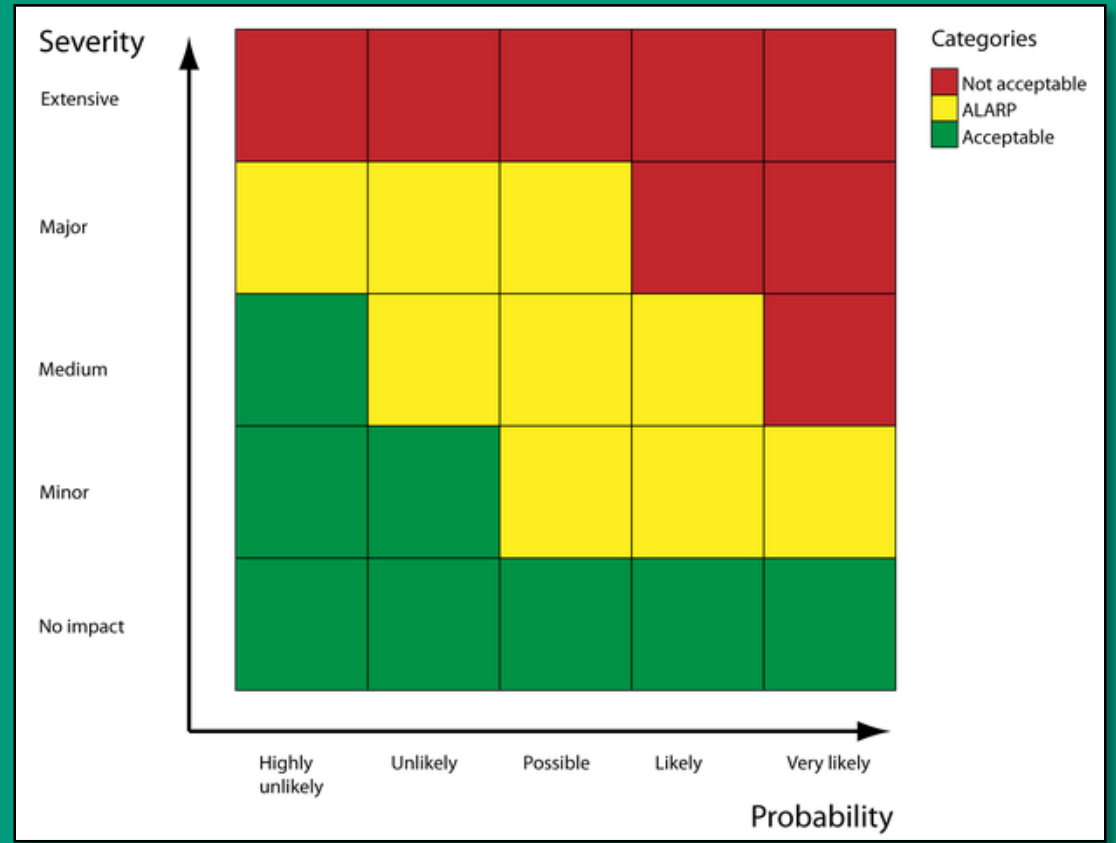
- Climbing Scaffolds or Ladders
- Getting on or off Equipment
- Handling Supplies or Material
- Machine Maintenance
- Walking or Running
- Other

016

Activity	Occurrence	Days Away from Work	Fatality	Likelihood of Accident Resulting in Days Away from Work (%)
Slips and Falls	346	142	1	41.0
Handling Materials	550	154	0	28.0
Machinery	196	54	1	27.6
Other	620	162	3	26.1

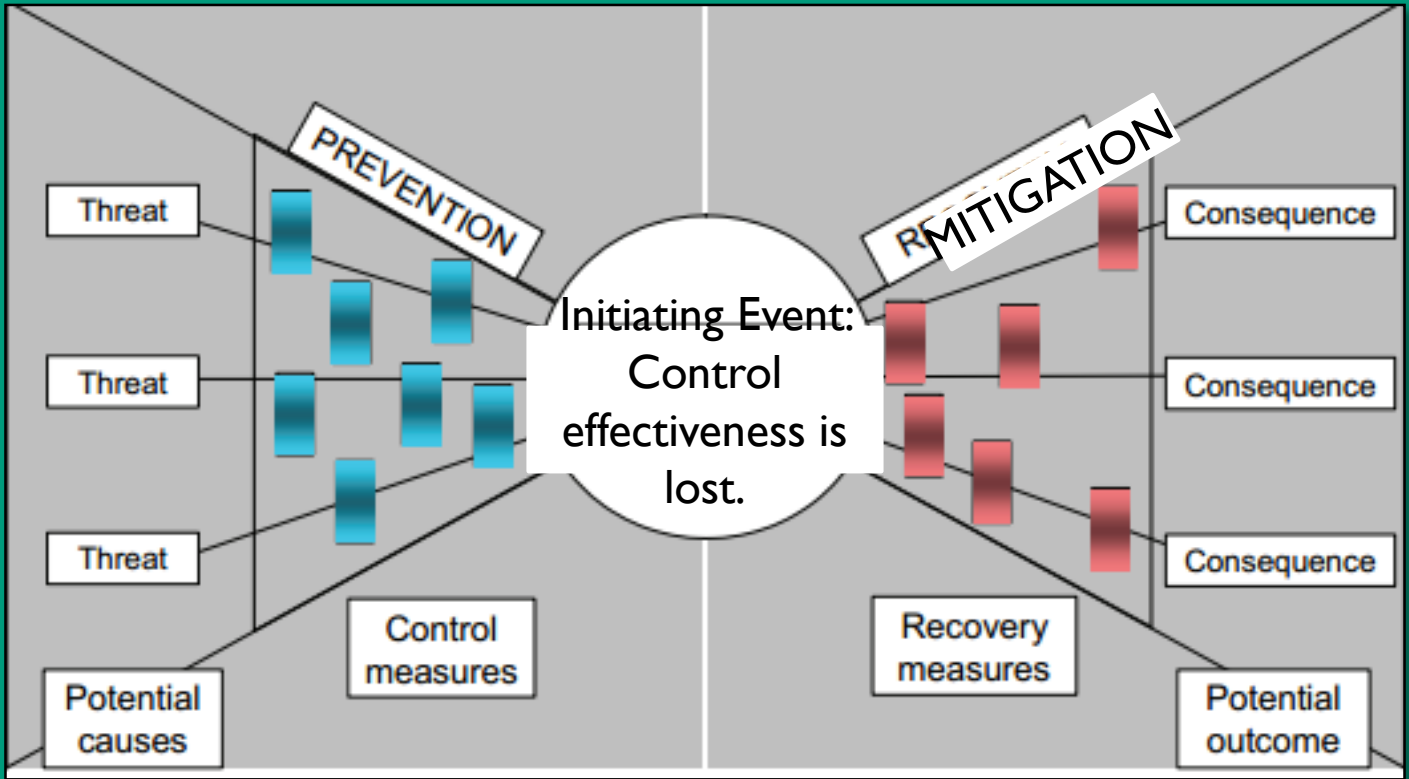
# RISK MATRICES

- Risk matrices are one of the most widely used tools for risk assessment. They are mainly used to determine the size of a risk and whether or not the risk is sufficiently controlled.
- It is important to understand that a risk matrix by itself makes for a poor decision making tool. It is best suited for ranking events. For priority, **RED** is **OK**.



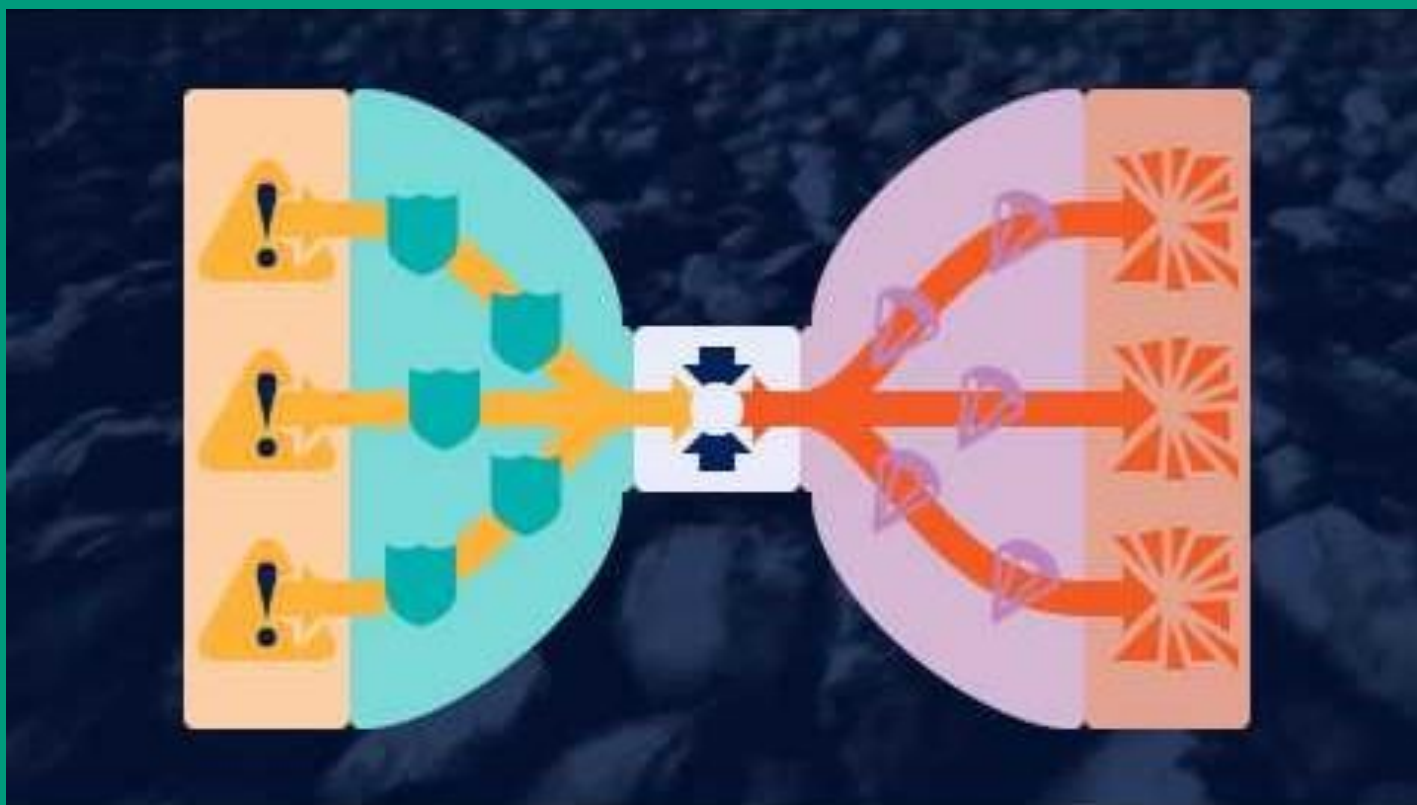


# BOW TIE ANALYSIS (BTA) METHOD





# RISKGATE



- <http://alpha.riskgate.org/>
- The risk presented by certain hazards can be defined as “**the effectiveness of control measures in place.**”
- Tolerable risk = Effective and adequate control



## BOW TIE ANALYSIS: PREVENTION VS. MITIGATION

- It is important to identify both controls which are intended to **prevent** the initiating event and controls which **mitigate** loss once the event has occurred.
- Use the seatbelt analogy: A seatbelt will not prevent a car accident (initiating event) from occurring, but a seatbelt can reduce (mitigate) the magnitude of injuries (consequence) sustained from the accident.





## BOW TIE EXAMPLE

- For the top event or hazard, “Fire or ignition in a sealed area,” categorize the following statements to form a bow tie.
- Injury to worker.

### Consequence

- Spontaneous combustion of coal.

### Potential Cause

- Ventilation and gas management of sealed area.

### Preventive Control

- Ventilation controls to limit the spread of fire.

### Mitigating Control



# RISKGATE – US EXAMPLE

**RISKGATE** US COAL

Home Topics About Downloads

## Bowtie Tool

The RISKGATE Bowtie selector below provides control information for Causes and Consequences relating to Initiating Events.

**Information**  
You can navigate through the Bowtie structure. Hovering over elements will provide more details. When you are ready please select the Checklist button.

**Checklist**  
[Click here to create a Checklist from this Bowtie](#)

**INITIATING EVENTS**

Click to restore full Bow-tie view.

Fires / Explosions:  
**Methane ignition resulting in fire (Face/Gob) or explosion**

**MITIGATING CONTROLS**

- Use seals which provide maximum resistance to explosive force (e.g. 120 psi seals)
- Ensure roadways are properly rock dusted
- Optimization of rock dust characteristics to prevent propagation of explosive force
- Monitoring to determine the extent of the affected area
- Implement comprehensive emergency response plan
- Provide adequate personal protective equipment (PPE) for miners (e.g. self-contained self-rescuers, lifelines, refuge chambers)
- Provide adequate training and ensure adequate awareness and competency of

**CONSEQUENCES**

- Fire in sealed gob area
- Explosion due to methane ignition**
- Regulatory action imposed due to methane ignition
- Methane ignition at longwall face
- Methane ignition in gob area at active longwall face
- Regulatory action imposed due to methane ignition
- Coal loss due to methane ignition
- Equipment damage or loss due to methane ignition
- Accumulation of toxic gases in mine atmosphere due to methane ignition and resulting fire/explosion

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■ <http://alpha.riskgate.org/>



## CONCLUSIONS

- Mining regulations in the U.S. have been **reactionary** over time and are **prescriptive** versus **risk based**
  - This has worked over time as incidents and fatality rates has decreased, but risk based could be beneficial as the industry strives toward “zero accidents”
  - Moving from Risk Matrices to Bowtie Tool has benefits, both are very useful
- Data on Accidents
  - It is better to have too much data than too little data on accidents
  - Data analysis has to take into account severity and potential risks to miners
- Mining Health and Safety research needs to be funded by government and industry working together with academia to create safer mines