

ANNUAL SUMMARY REPORT ON MOLTEN METAL INCIDENTS FOR 2020

October 2021

For the year **2020**, **143** molten metal incident reports occurring world-wide were received as compared to **163** reports received for **2019** and **170** reports for **2018**. The attached figures summarize the reports for 2020 as well as the data for the years 1980 thru 2020.

SUMMARY POINTS:

- For 2020, there were 143 explosion incidents reported, which continued the downward trend in reported incidents over the previous 3 years. The 2020 total incidents are somewhat lower than the historically high incidents (170 – 195) reported over the previous five years but are still in the high range of increased reporting starting in 2015.
- There were 130 Force 1 explosions, 12 Force 2 explosions and one Force 3 explosion reported in 2020. Compared to 2019, the main difference was a reduction from 27 to 12 Force 2 explosions. The number of Force 1 and 3 reported explosions being essentially the same.
- Of note, there were no reported fatalities in 2020. Over the past 10 years there were only two years with Fatalities: 2014 with one and 2018 with 8 which involved two Casting incidents in China.
- The 1.0/yr. average fatality rate for the past 10 years is significantly lower than the 2.5 annual rate for the entire length of the program.
- Of high significance, there were only 7 reported injuries in 2020, all Minor (no Serious injuries or Fatalities) and this is the lowest number of injuries ever reported since the beginning of incident reporting in the 1980's! The second lowest year was 2017 with 8, also all Minor injuries.
- The 7 Minor injuries occurred in the following Operations: One during Melting (Force3): Three during Transfer (all Force 1); and three during Casting (1-Termination (Force2); 2-Start-up (both Force 1)).
- As has been noted in other years and is observed in the new charts added to the report last year, there are more injuries occurring in Transfer operations per incident compared to the other operations. As an example, in 2020, Transfer Operations had three injuries in 19 incidents, while Casting Operations had three injuries in 62 incidents.
- SMM News, a Chinese Metal Information Provider, published a story in Sept. 2020 regarding a major Force 3 explosion that occurred in the Hongda Aluminum Profile Co., Gansu Province. Three fatalities and 7 injuries were reported in the article. Since the

Aluminum Association did not receive any official documentation regarding this incident it has not been included in the Annual Summary. Although the English translated publication was not entirely clear, it could be interpreted that the incident occurred near the end of an operation with molten aluminum spilling into cooling water and then a large explosion occurring.

- The single Force 3 incident occurred during a Charging operation. The likely cause of the explosion involved a stack of sows with snow on them being charged along with the presence of residual molten aluminum in the furnace and less than adequate bedding scrap. The charging operator in the cab with open doors received two small first degree burns to the face.
- The total of 12 Force 2 incidents was noticeably lower than the higher numbers reported in the previous 3 years, which were centered at the overall average since reporting started in the early 1980's of 21 incidents/yr. This volume of Force 2 explosions was in-line with the downward trend noted from 2010 through 2015.
- For 2020, half of all the Force 2 explosions (6) occurred in Melting, all related to wet scrap. There were zero Transfer Force 2 incidents. The 5 Force 2 Casting incidents involved two at Start-up, one in Steady-State and two at Termination. Reduction operations reported one Force 2 incident.
- Injury rate per incident has been trending downward over the past 5-10 years for all three operations, Melting, Casting and Transfer, which was observed in new charts added to the report last year.
- When comparing average injuries/year for the years 2001-2015 vs. 2016-2020, the latter category is significantly lower for all categories of injury, Minor, Serious and Fatal. Average Fatal / Yr. were reduced 36%, average Serious / Yr. were reduced 64%, average Minor / Yr. were reduced 75% and Average Total injuries / Yr. were reduced 71%.
- As stated in the past, this lower injury frequency can be attributed at least partially to 1) the increased use of primary and secondary PPE; 2) improvements in PPE materials and design; 3) an increased focus on hands-free casting operations that remove personnel from high-risk casting operations; and 4) possibly increased training and hazard awareness.
- Two years in the past 10 years standing out were 2015 and 2018 with high numbers of injuries: 1) one 2015 Force 3 Melting explosions with 35 minor injuries; and 2) two 2018 China Force 3 casting explosions with 25 injuries, including 8 fatalities.
- Most explosions occurred during the Casting operation (62) with the Melting operation incidents (55) slightly lower. In total for the entire incident program, Casting incidents (1498) are slightly higher than Melting incidents (1456). Historically Melting operation incidents were higher than reported for Casting, however this trend was reversed starting in 2003.
- There were no Recycling Plant injuries in 2020! There were 28 Force 1 and three Force 2 incidents reported from Recycling Plants.

- In 2020, most explosions occurred in Reduction process plants, followed by Rolling. Reduction and Rolling each experienced 4 Force 2 incidents, with Recycling having 3 and Extrusion one. The one Force 3 Incident occurred in Rolling, which historically has had the highest number of Force 2 & Force 3 incidents, while Reduction has had the highest number of incidents.
- New analysis and charts were added to the 2020 Report and updated this year which reviews the major causes of Casting and Transfer explosions over recent years. These charts highlight that most Force 2 & 3 Casting explosions are caused during DC cast starts due to excessive curl / hang-up / bleed-out, while most Transfer Force 2 & 3 explosions are due to wet / rusty drain pans. For these large Force 2 & 3 Transfer explosions, wet / rusty drain pans cause almost 3 times the number of incidents as the next leading cause!
- One single large company reported 50 incidents with zero injuries. When asked, keys they listed that contributed to preventing injuries were:

People (operators):

- Daily meetings on safety and risks management
- Introduction of some good practices like: Take 5, Stop and Help Request
- Regular Interactions by supervision on safety hazards
- Regular training on safety hazards
- Standardization of PPE thru the organization

Engineering:

- Elimination of the risks: Hands-off VDC starts (Slab and billets) for the first 500mm of a cast start
- Measurement systems: Dew point devices in every company location
- Process Safety Program including the Process Hazard Assessments on DC pits, lightning, dust management, natural gas
- Aluminum scrap preheaters installed in every company location

Management Systems:

- Written Standards: Molten Materials and Remelting Rules
- Yearly audits by experts in every plant to review standards in place
- Critical Risks Management program: Daily audits from plant management on critical risks, which include molten metal management

EXPLANATION & DISCUSSION OF CHARTS AND DATA:

The Aluminum Association classifies molten metal explosions according to Force level, with Force 1 being the least severe and Force 3 being the most severe. Table 1 below provides information on the criteria used for rating Force level. Figures 1 through 43, provided after the discussion below, display various charts and tables, including Table 1.

Table 1: Explosion Rating Force Criteria



Guidelines	Force 1	Force 2	Force 3
Property Damage	None	Minor	Considerable
Light	Minimal	Flash	Intense
Sound	Short cracking	Loud Report	Painful
Vibration	Short and sharp	Brief rolling	Massive structural
Metal Dispersion	<15 feet	>15 to 50 feet	>50 feet

Figure 1 displays by year from 1981 thru 2020 the total number of reported incidents, **4192**. The **143** explosions reported in 2020 continue a downward trend over the past three years, but still in the same higher range of an increased reporting level starting in 2015. There has been an average of 171 incidents/year reported over the past 6 years, compared to an average of 145 incidents/year from 2000 through 2007 and 83 incidents/year from 2008 through 2014.

Figures 2 thru 6 provide **Force Level** data for the years 1981 thru 2020 in various formats, including the number of incidents and rates. **Figure 2** displays the reported incidents each year for all three Force Levels. In 2020 there were **130 Force 1**, **12 Force 2** and **one Force 3** explosions. Compared to 2019, the main difference was a reduction in **Force 2** incidents from **27** to **12** explosions.

Another **Force 3** incident was reported to have occurred in China in 2020. The Aluminum Association did not receive any official documentation, so this incident is not included the 2020 Annual Summary data. SMM News, a Chinese Metal Information Provider, published a story in Sept. 2020 regarding a major Force 3 explosion that occurred in the Hongda Aluminum Profile Co., Gansu Province. Three fatalities and 7 injuries were reported in the article. Although the English translated publication was not entirely clear, it could possibly be interpreted that the

incident occurred near the end of an operation, possibly casting, with molten aluminum spilling into cooling water and then a large explosion occurring. The following is a direct quote from the SSM NEWS, Sept. 7, 2020, translated article: *“According to the investigation after the event, near the end of production, the workers in the melting and casting workshop caused leakage due to improper operation, resulting in residual aluminum liquid leaking into the cooling water of deep wells, resulting in a large number of steam shock waves, resulting in flash steaming, resulting in a safety accident in the production of cooling water flash.”*

Figure 3 shows the data for only **Force Levels 2 and 3** and **Figure 4** displays only **Force Level 3**. Both **Figure 3 and Figure 4** include the average number of explosions per year for this time frame. From 2008 through 2020 there has been either zero or **one Force 3** explosion reported annually with one exception in 2018 when **two Force 3** explosions were reported. Both occurred in China. The average number of **Force 3** explosions over the last 5 and 10 years (1.0/yr. and 0.8/yr. respectively) continues to show a much lower level compared to the 2.9/yr. average for the entire reporting history from 1981 through to 2020. The notable downward trend of **Force 2** explosions observed in **Figure 3** starting around 2008 and continuing through 2014 was reversed beginning in 2016 and has continued through 2019 with an average of **22/yr.** over those 4 years. This upward trend was reversed in 2020 with **12 Force 2** incidents.

Slightly more of the **Force 2** explosions in the last 5 years occurred in **Casting** (46) vs. **Melting** (43). The balance of the Force 2 incident occurred equally in **Transfer** (6) and **Other** (6). This is atypical of historic data where **Force 2** explosions predominately occurred in **Melting** by a wide margin.

Figures 5 and 6 display a comparison of all three **Force Levels** for the entire reporting history from 1981 through 2020 in two different formats: 1) bar graph and 2) pie-chart. **Force 1** incidents account for **76.1%** of all incidents, up slightly from 2019 which was at **75.6%**. And conversely the **Force 2** incidents lowered from **21.5%** in **2019** to **21.0%** in **2020**. The **Force 3** total stayed the same at **2.9%**.

Figures 7 thru 12 provide in various formats of injury incident data (**Minor, Serious and Fatal**) for the years 1981 thru 2020. The **Figure 7** bar chart shows **Minor, Serious and Fatal** injuries for each year. In 2020 there was a total of only **7** injuries, all **Minor**. This is the lowest number of injuries in any year since the beginning of the incident reporting in the 1980's. The second lowest was **2017**, with **8** total injuries all **Minor**. The last reported **Fatalities** were in **2018** as the result of two **Force 3** China explosions accounting for **8 Fatalities, 2 Serious** and **2 Minor** injuries. From **2008** through **2020** there have been **4 Fatalities**, excluding the **8 Fatalities** in **2018**.

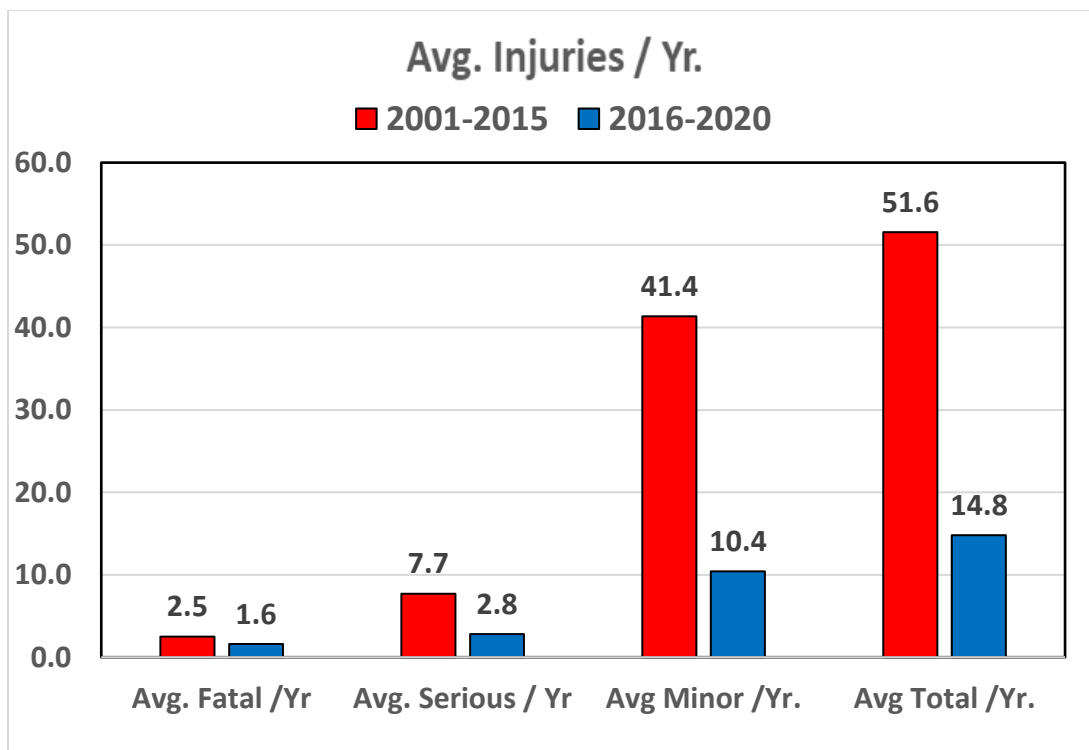
From 1981 through 2020, there is now a total of **1605 Minor, Serious and Fatal** reported injuries with **Figure 8** showing the total injuries in these three categories. The **Figure 9** pie chart breaks this down into percentages: **69.9% Minor, 23.9% Serious** and **6.2% Fatal**.

Figure 10 presents the likelihood of no injury per 100 incidents vs. the likelihood of an injury in each injury category. This indicates that for each 100 incidents reported there is a **26.8%** rate for **Minor** injuries, a **9.2%** rate for **Serious** injuries and a **2.3%** rate of a **Fatality** vs. a **61.7%** rate of **No Injury**. All three of these injury rates decreased in 2020 vs. 2019 percentages. Since explosions are typically more likely to be reported when there is an injury of some degree, these numbers are certainly inflated compared to data if all explosions were reported, but this does provide an indication of the potential rate of an injury per incident.

Figure 11 displays data only related to **Fatalities** for the reporting program from 1981 through 2020. There have been **10 fatalities** over the past 10 years, with 8 of the 10 reported in 2018, as previously noted, due to the **two Force 3** casting explosions in China. The **1.0/yr.** average fatality rate for the **past 10 years** is significantly lower than the **2.48** annual rate for the entire length of the program.

Figure 12 is a new chart for this 2020 Summary Report and is also shown as **Chart 1** below. This chart displays **Average Injuries per Year** for the years **2001** through **2015** and for the last 5 years, **2016** through **2020**. It can be easily observed that there has been a significant reduction in total injuries per year for the last 5 years compared to the previous 15 years (**14.8 vs. 51.6**). This is also noted for all three categories, **Minor**, **Serious** and **Fatal**.

Chart 1



Average Fatal / Yr. were reduced 36%, average Serious / Yr. were reduced 64%, average Minor / Yr. were reduced 75% and Average Total injuries / Yr. were reduced 71%. This noted significantly lower injury frequency over the past five years can be attributed at least partially to:

1) the increased use of primary and secondary PPE; 2) improvements in PPE materials and design; and 3) an increased focus on hands-free casting operations that remove personnel from high-risk casting operations.

Figures 13 thru 43 provide more detailed information regarding the **143** reported explosions in **2020** along with similar charts comparing this yearly data with the entire database from 1980 thru 2020. Additionally, there are newer charts, first presented in the 2020 report last year, that provide further insight into: 1) Recent trends in reported explosions and injury rates for **Melting, Casting and Transfer** operations (**Figures 15-20**); and 2) Summaries of the major causes of **Casting and Transfer** incidents over recent years (**Figures 26, 27, 30 & 31**).

Figure 13 shows the 2020 data by **Force Level** for each of the four major categories of operations: **Melting, Casting, Transfer and Other**. This can be compared to the same data for the years 1980 thru 2020 in **Figure 14**. In 2020, most explosions occurred in **Casting (62)**, with **Melting (55)** slightly lower, **Transfer (19)** and **Other (7)** being lowest as usual. All **Other** explosions occurred in the **Reduction** Process. The **12 Force 2** incidents in 2020 is a reduction over the average of 22.3 for the previous 4 years. **Melting** and **Casting** had similar numbers of **Force 2** incidents, **6** and **5** respectively.

The lone **Force 3** explosion reported in 2020 was during a **Casting** operation in a **Rolling** plant. This was reported to have occurred when snowcapped 1500 lbs. sows were charged into a melter with residual molten metal and less than adequate bedding scrap. One employee received minor injuries and there was heavy building damage.

Most **Force 2** and **Force 3** explosions for the entire reporting period continues to be related to the **Melting** operation by a wide margin as shown in **Figure 14**.

As discussed in previous years and shown above in **Figure 7**, there appears to be a downward trend with injuries. **Figures 15 through 20** provide **Injury** and **Incident** data for each **Melting, Casting and Transfer** operations in two different formats: 1) **Injuries** and **Incidents**; and 2) **# Injuries per Incident** or **Injury Rate**. Data is displayed by year from 1990 through 2020, excluding 2011. Unfortunately, the data is not available for program years prior to 1990 and 2011.

In general, the data shows an up-swing in incidents in the early 2000's and a higher incident volume for the last 6 years. There is downward trend over the last 5 years after a peak in 2016. as is seen previously in **Figures 1 and 3**. In contrast, however, there appears to be downward trend in **Injuries per Incident** or **Injury Rate** over the last 7 to 10 years. A downward trend can be observed especially for the **Casting and Transfer** operations (**Figures 18 and 20**). **Melting injuries** and **Injury Rate** have been very low for the last 10 years (< 0.05), except for 2015 (>0.7), which had **35 Minor** injuries resulting from one **Force 3** explosion when a furnace bled-out into a casting pit.

For the **Injury per Incident Rate** charts a best fit line is provided along with R^2 values, which are very low due to the scatter in the data. It is an obviously a positive sign that the **Injury Rate** is trending in this direction over the past several years. There are probably numerous reasons for this trend including improvement with primary and secondary PPE materials, design and use, movement toward 'hands-free' casting removing personnel from the casting pit during cast starts, and increased training and hazard awareness.

Figure 21 provides 2020 data regarding the type of charge materials involved in **55 Melting** incidents. As in the past, wet or contaminated scrap along with wet alloy (including Mg, Si and salt flux) were the leading causes of **Melting** explosions, with **48 Force 1, 6 Force 2 and 1 Force 3** incidents in this category.

Figure 22 provides a compilation of the **Melting** explosion data over the years 1980 thru 2020 for the various types of charging material involved. Wet or contaminated scrap continues to be the reason for most of the **Melting** explosions. The second highest area is related to wet alloying materials. Most of the **Force 2** and **Force 3 Melting** explosions have been related to **Scrap** charging. Most other Force 2 and Force 3 explosions are related to charging various types of sows (primary and RSI) and T-bar.

Figure 23 provides a breakdown of the **62 Casting** incidents in 2020 in two different ways: by stage in the process and by type of casting process. There were **5 Force 2** and **0 Force 3** explosions in 2020. As typically seen in the past, most of the explosions occurred during **Start-up (51)**, with **three** during **Steady-State** and **7** during **Termination**. Most of the **Casting** incidents (**39**) occurred when casting **Sows** or **Molds. DC Billet or Slab** had **22** incidents, which was untypically lower than the **Sow** and **Mold** category.

Figure 24 shows **DC Casting** incidents by drop segment for years 1980 - 2020. The historical data is similar to the 2020 data shown in **Figure 23** in that most explosions occur during **Start-up**. There was a higher percentage of **End-of Cast** explosions again in 2020 compared to **Steady-State**, which is opposite of the historical data.

For 2020, **Figure 25** provides the major causes of the **61 Casting** incidents. They are listed by cast stage for DC casting and for mold or sow casting. For DC casting, the main issues were related to wet starting blocks, wet equipment or launders, equipment set-up and failure, hang-ups and bleed-outs, mold water issues and SOPs not adapted or not followed. The main sow and mold casting incidents were due to wet or cracked molds, and wet equipment or tools.

Figures 26 and **27** were new charts starting last year that provide additional analysis of the primary causes of **Casting** explosions, looking at the last 6 years of data, **2015** through **2020**. **Figure 26** shows the major causes for all Force levels, while **Figure 27** is data for only **Force 2** and **3 Casting** explosions. By a large margin, the reason for most **Casting** explosions at all **Force** levels is wet, cracked or rusty sow molds. This is followed by excessive curl / hang-up / bleed-out

explosions during DC cast starts, which is also the highest cause if segregating for **Force 2** and **3** incidents only, **13** in total for these 6 years. The next two highest causes of **Force 2** and **3** incidents are wet, cracked or rusty sow molds (**8**) followed by DC casts and aborts – wet / rusty drain pans (**7**).

There were **19 Transfer** explosions in 2020 as shown in **Figure 13**, all **Force 1**. **Figure 28** shows that wet transfer equipment (**7**) accounted for the highest number, followed closely by wet or rusty drain pans or molds (**6**).

Figure 29 provides a bar chart showing the equipment involved in **840 Transfer** explosions for the years 1980 thru 2020. The highest number of **Transfer** explosions are related to **Drain Pans**, followed by **Trough** and then **Other**.

Like **Figures 26** and **27** presented above for **Casting**, **Figures 30** and **31** were first presented last year, providing further detail regarding the major causes of **Transfer** explosions. **Figure 30** provides the data regarding the major causes of all **Transfer** explosions for the years **2008** through **2020** (excluding 2011), while **Figure 31** provides this information for only **Force 2 & 3** explosions. Since there were only **Force 1 Transfer** incidents reported in 2020, the chart is the same as last year. Wet / rusty drain pans is the main cause of explosions for both categories. It can be noted in the **Force 2 & 3** data, that wet / rusty drain pans cause almost 3 times the number of incidents compared to the next leading cause of wet refractory / equipment.

Injuries by Operation (Melting, Casting, Transfer and Other) resulting from the 143 explosions in 2019 is shown in **Figure 32**. All **7** injuries were **Minor**, with **three** each in **Casting and Transfer** and **one** in **Melting**.

Figure 33 provides **Injury by Operation** data for 1980 thru 2020. The highest number of **Minor** and **Serious** injuries has occurred in the **Casting Operation**. The **Melting Operation** accounts for the highest number of **Fatalities**, also the highest number of **Force 3** explosions as seen in **Figure 14**. It should be noted that a significant number of injuries have occurred in **Transfer Operations**, including **81 Serious** and **7 Fatalities**, occurring even from this typically rather straight forward procedure. As a comparison in 2020, **Transfer Operations** had **three** injuries in **19** incidents, while **Casting Operations** had **three** injuries in **62** incidents.

Figures 34 and **35** provide incident data vs. the type of **Process Plant (Reduction, Extrusion, Rolling and Recycling)** for 2020 and for 1980 thru 2020 respectively.

In 2020, the highest number of incidents occurred in **Reduction** Operations (**66**), compared to the next highest **Rolling** Operations (**38**). These two operating areas also each had **4 Force 2** incidents. These results are in line with the data shown in **Figure 35 for the entire reporting period**, 1980 thru 2020, with the highest number occurring in **Reduction** and the second highest

reported from **Rolling**. However, by far the highest number of **Force 3** explosions have occurred in **Rolling**.

The main causes of the 2020 **Reduction** facility explosions are presented in **Figures 36** and **37**. They are listed by **Melting, Casting** and **Transfer / Reduction** incidents. **Melting** incidents were related to wet charges and wet tools. The primary reason in **Casting** was cracked, wet or rusty molds for sow casting. **Transfer** and **Reduction** incidents were primarily related to wet refractory, wet equipment and tools and wet molds.

Figure 37 is a bar chart providing **Reduction** plant injury information for the **two Minor** Injuries in 2020. There were no Serious Injuries. The **two** injuries were both **Transfer** related with bath spilled on a wet floor and a wet pan.

Rolling plant injury information is shown in **Figure 39**, which included **3** injuries, all **Minor**. There was one each in **Melting** (charging snow covered sow), **Casting** (during bottom block fill) and **Transfer** (wet refractory).

For **Extrusion, Figure 40**, **two Minor** injuries occurred, both in **Casting**: one at **start-up** due to a wet starting block and one at **Termination** due to a wet/ rusty drain pan.

There were **zero Recycling** plant injuries in **2020** as noted in **Figure 41**!

Figure 42 summarizes the 2020 injury data by type of **Process Plant** and **Figure 43** shows this same data for 1980 thru 2019.

The last page of the report after the Figures provides an Aluminum Association Molten Metal Incident Report Form or you can link to the form at:

<https://www.aluminum.org/resources/electrical-fags-and-handbooks/safety>

RTR – October 7, 2021



Incidents by Year 1981 to 2020 Total 4192

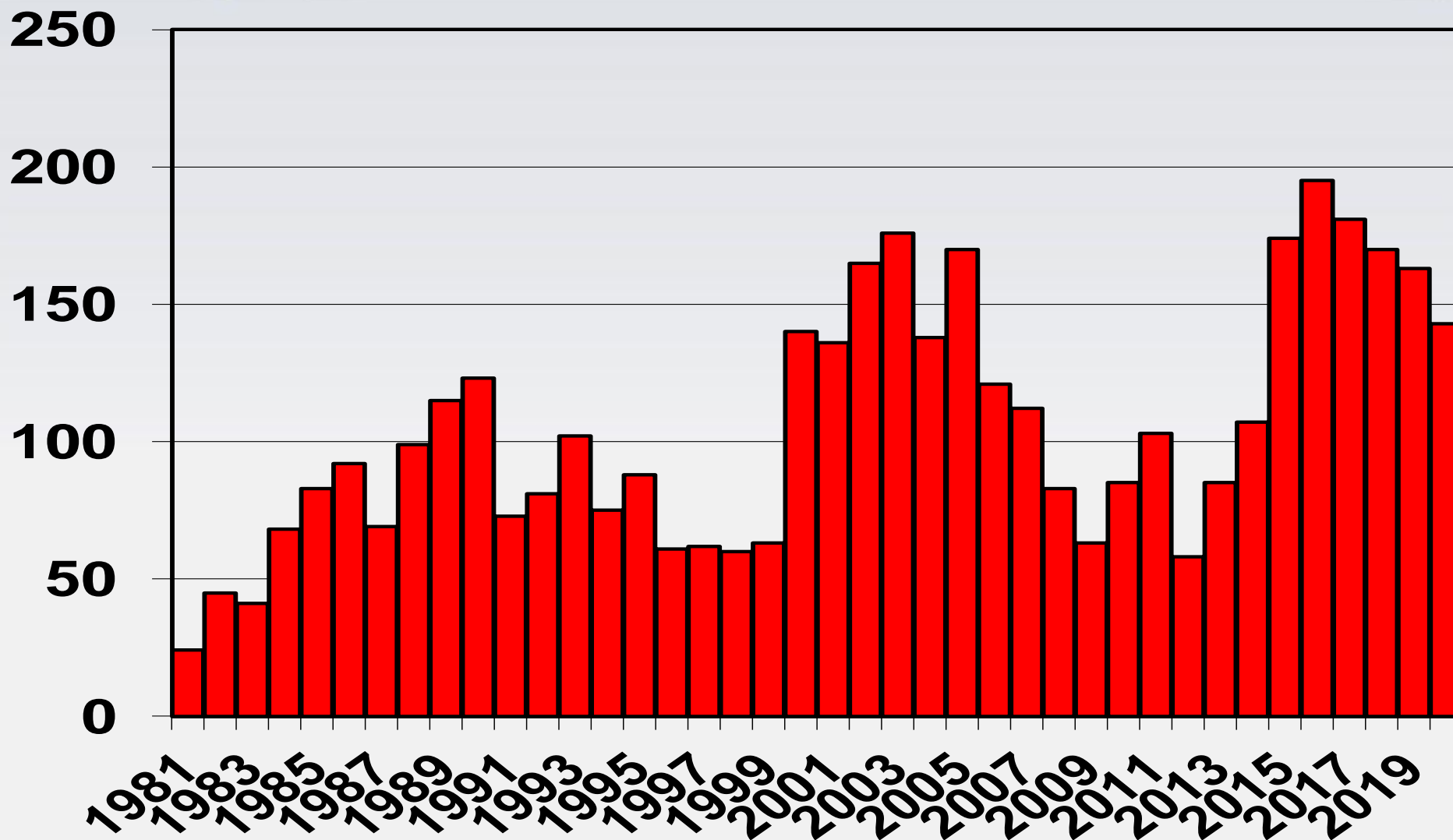


FIGURE 1. INCIDENTS REPORTED FOR THE PERIOD 1981 – 2020 Oct. 2021

Explosion Rating Force Criteria

Low

Severe



Guidelines	Force 1	Force 2	Force 3
Property Damage	None	Minor	Considerable
Light	Minimal	Flash	Intense
Sound	Short cracking	Loud Report	Painful
Vibration	Short and sharp	Brief rolling	Massive structural
Metal Dispersion	<15 feet	>15 to 50 feet	>50 feet

Table 1. Explosion Rating Force Criteria

Oct. 2021

Incidents by Force Level 1981 to 2020 – Total 4192

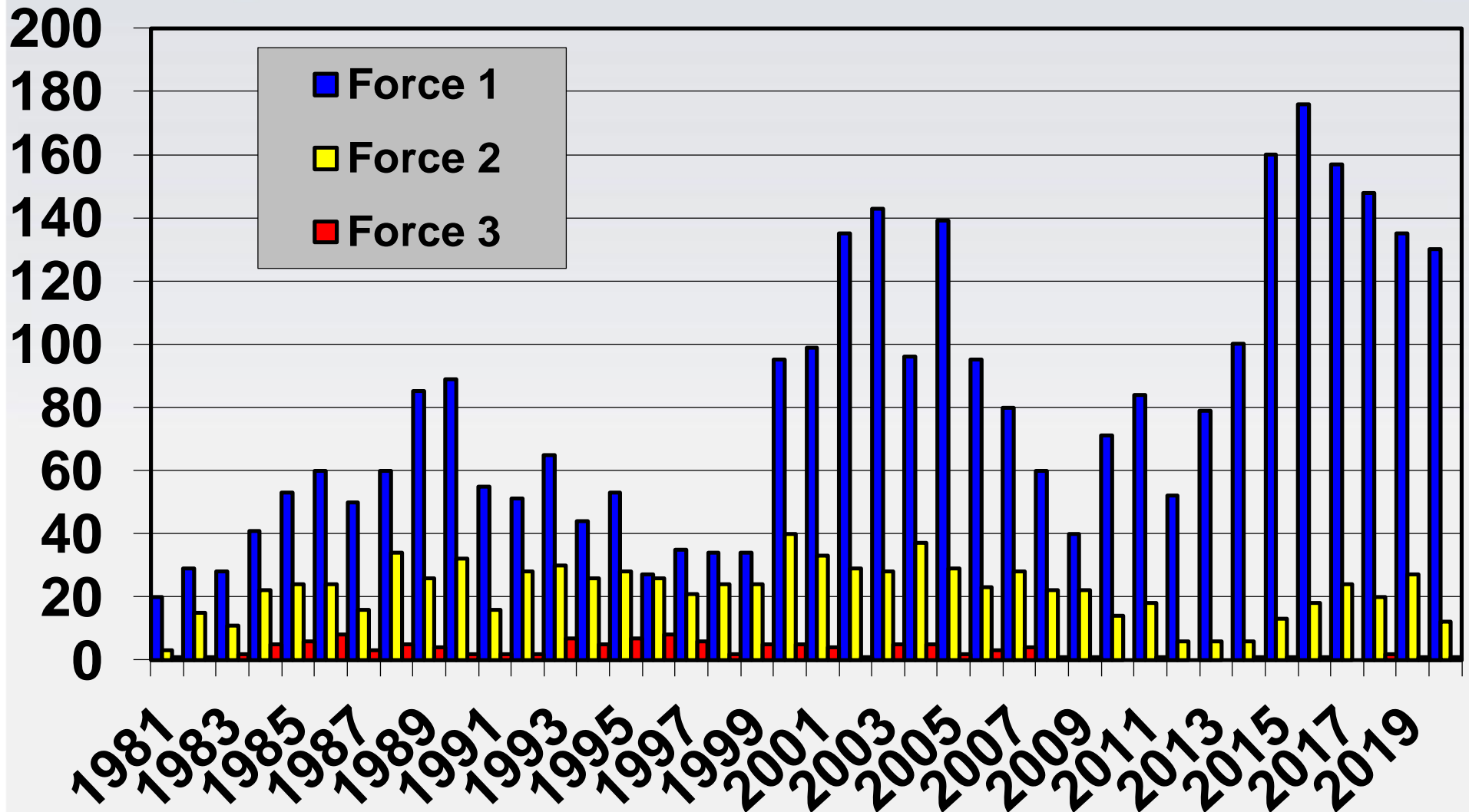


FIGURE 2. INCIDENTS BY FORCE LEVEL FOR 1981 – 2020

Oct. 2021

Incidents by Force Levels 2 & 3 1981 to 2020

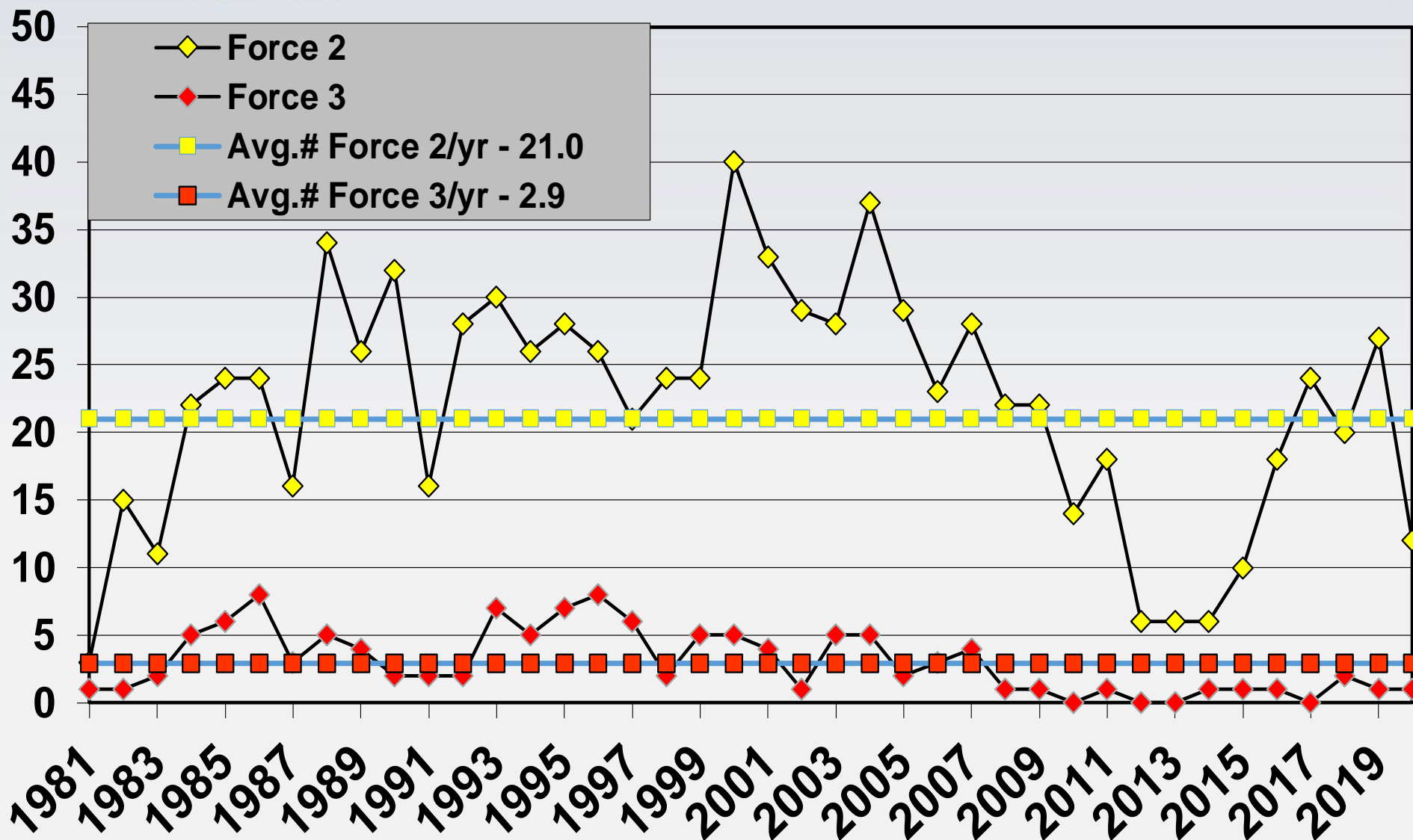


FIGURE 3. INCIDENTS BY FORCE LEVELS 2 & 3 FOR 1981 – 2020 Oct. 2021

Force 3 Incidents Only 1981 to 2020

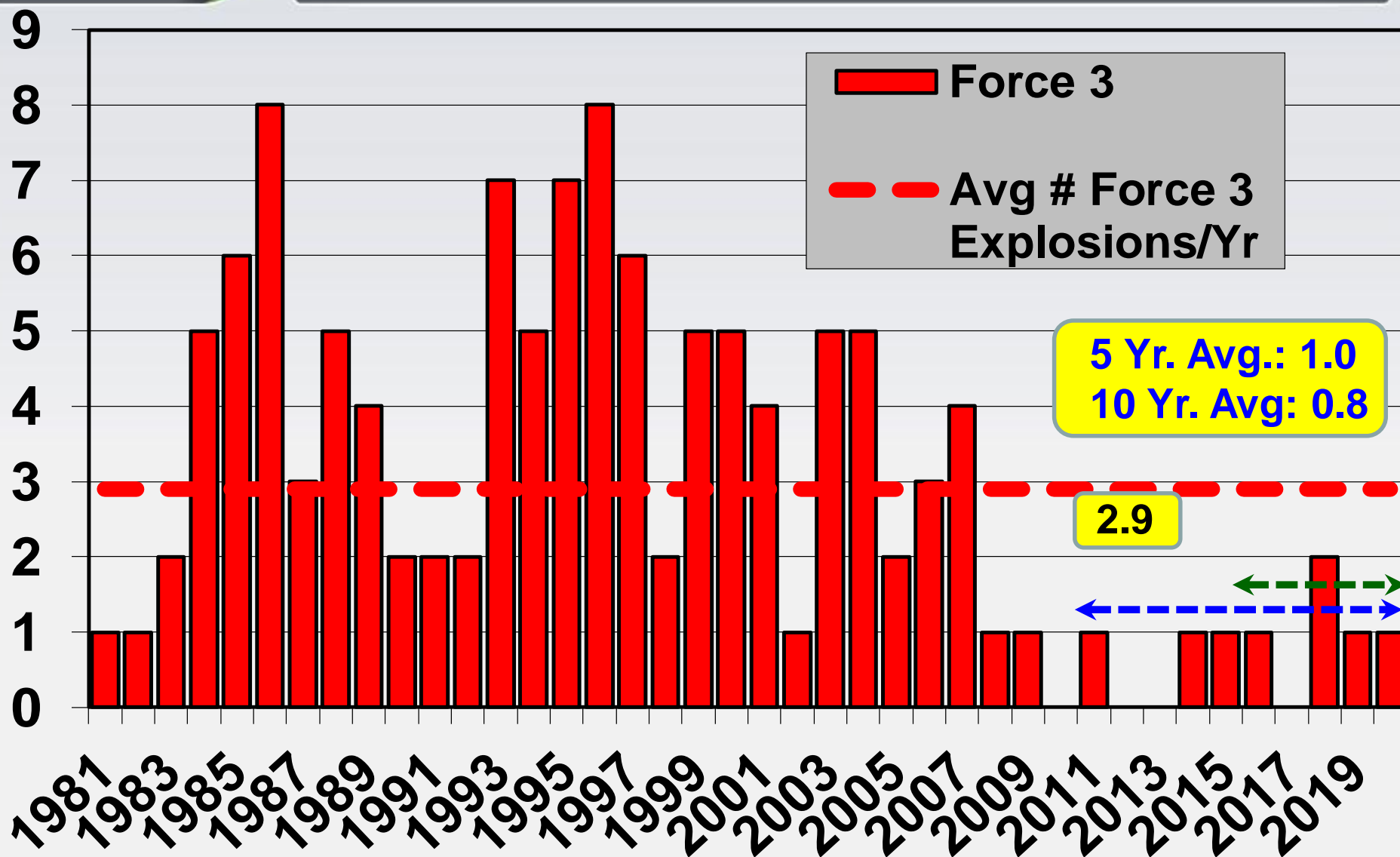


FIGURE 4. FORCE 3 INCIDENTS FOR 1981 – 20120

Oct. 2021

Incidents by Force Level 1981 to 2020 – Total 4192

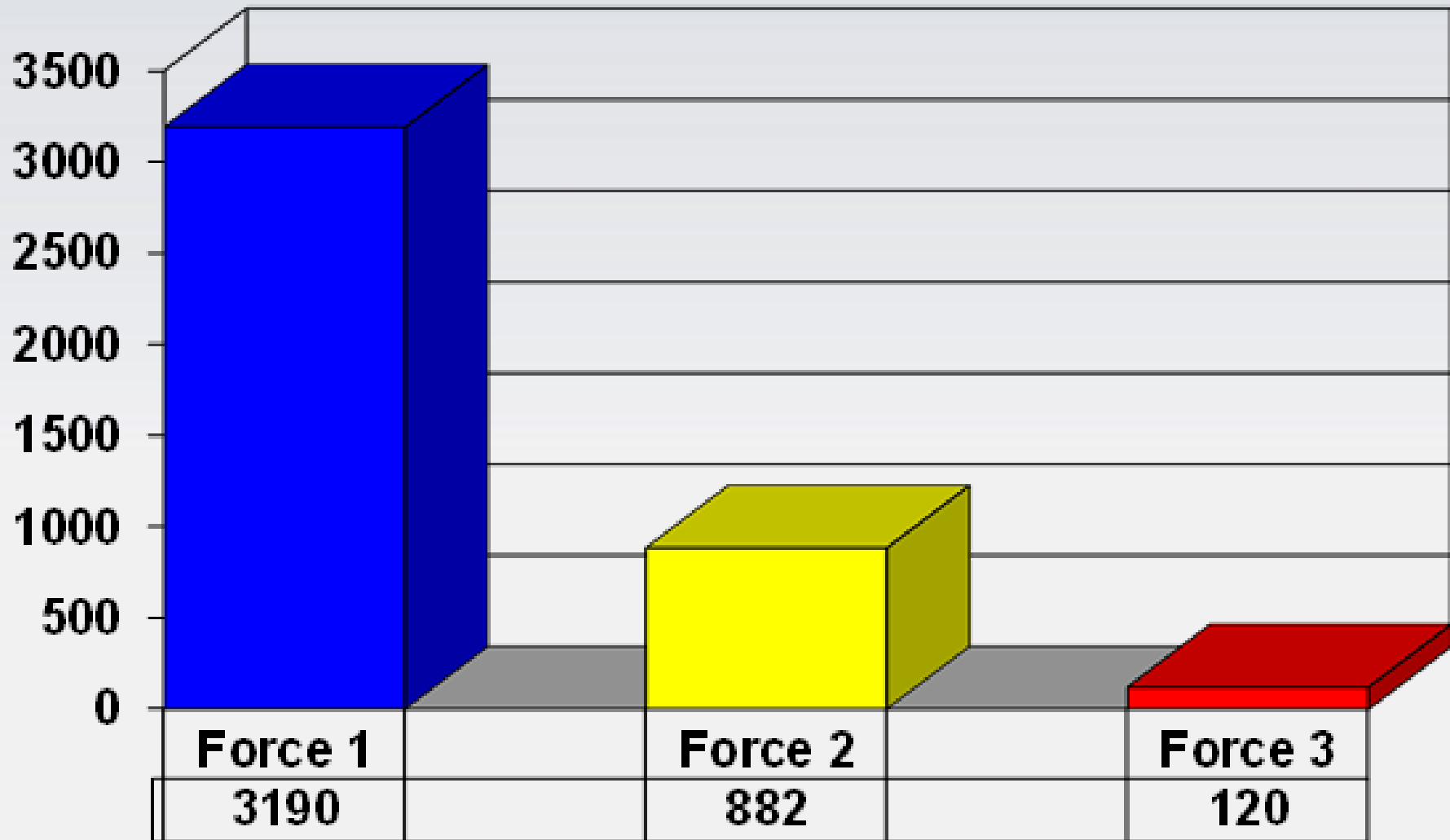


FIGURE 5. INCIDENTS BY FORCE LEVEL 1981 – 2020

Oct. 2021

All Force Levels by Percentage 1981 - 2020

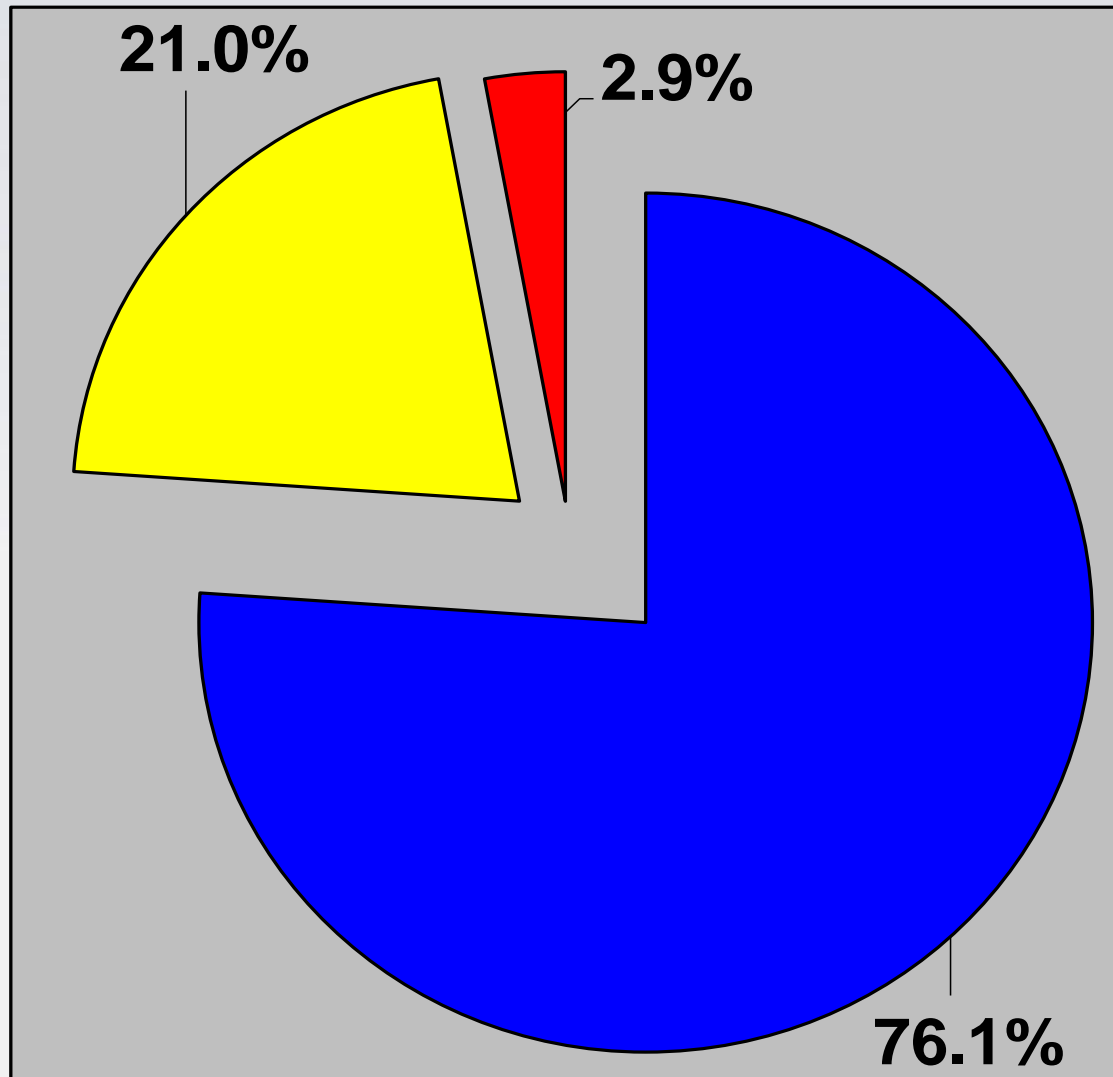


FIGURE 6. ALL FORCE LEVELS BY PERCENTAGE 1981 – 2020

Oct. 2021



Injuries from Incidents 1981 to 2020 (Total 1605 Injuries)

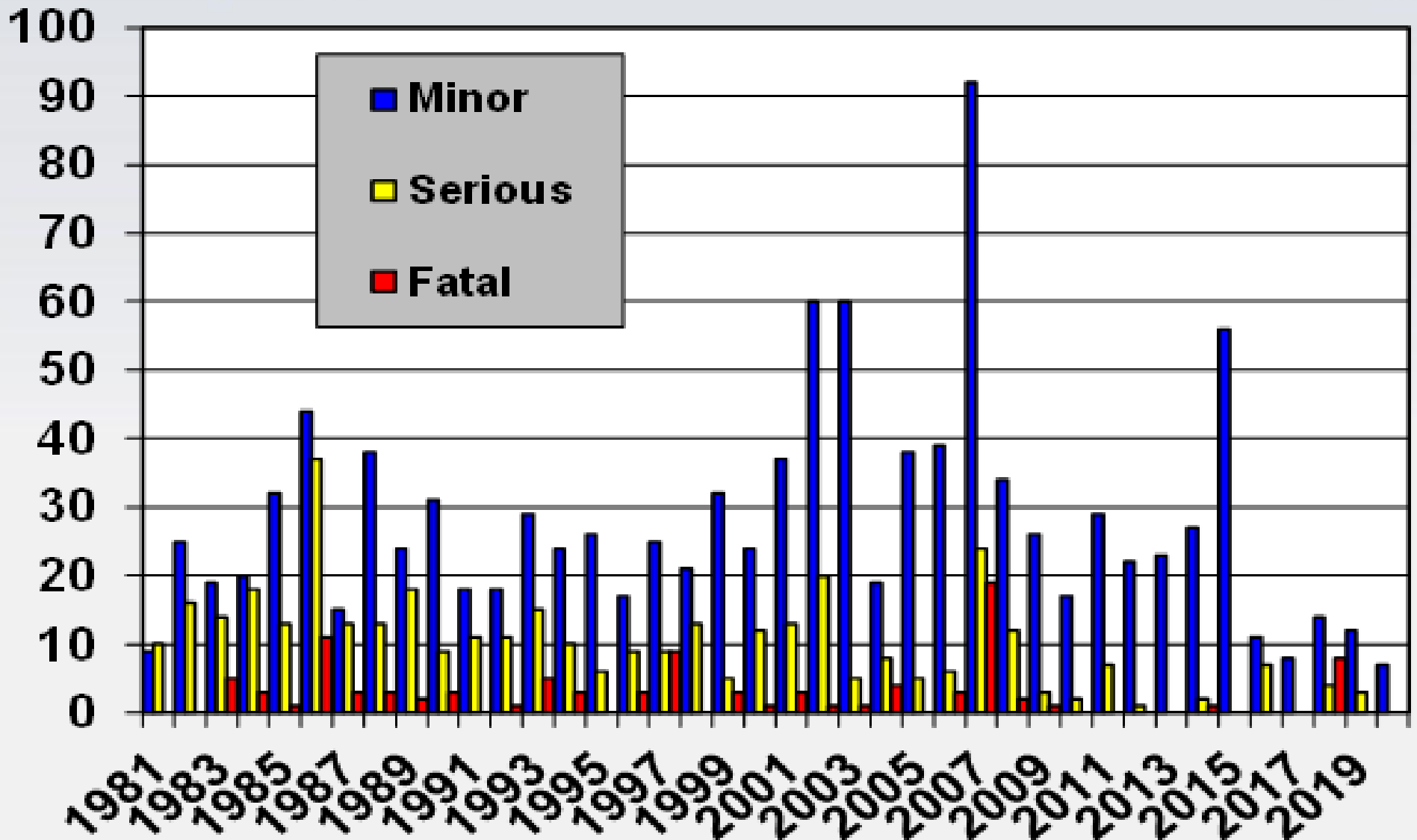


FIGURE 7. INJURIES FROM INCIDENTS FOR 1981 – 2020

Oct. 2021

Injuries by Severity – Total 1605 1981 to 2020

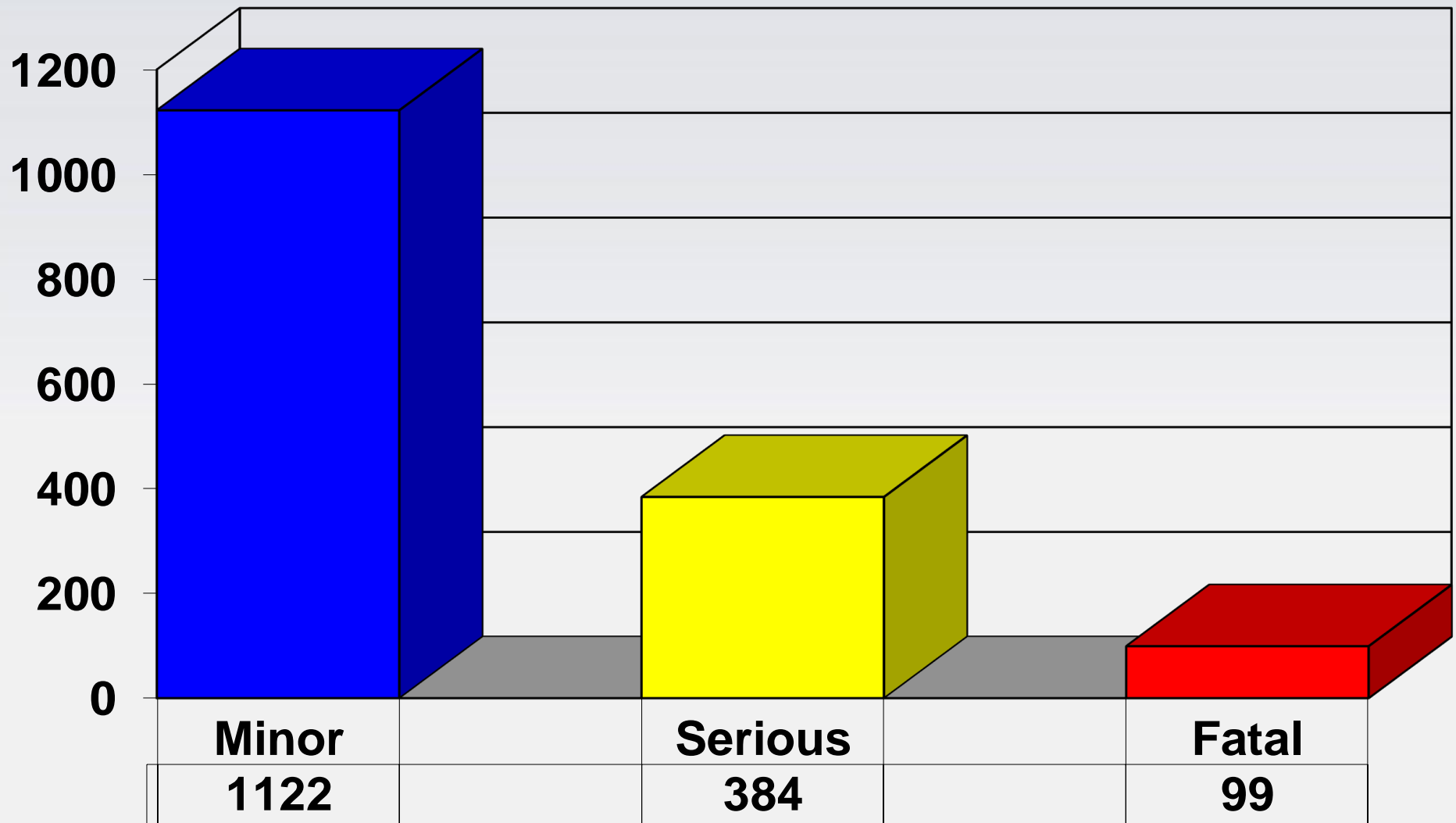


FIGURE 8. INJURIES BY SEVERITY FOR 1981 – 2020

Oct. 2021

Injury Levels by Percentage 1981 - 2020

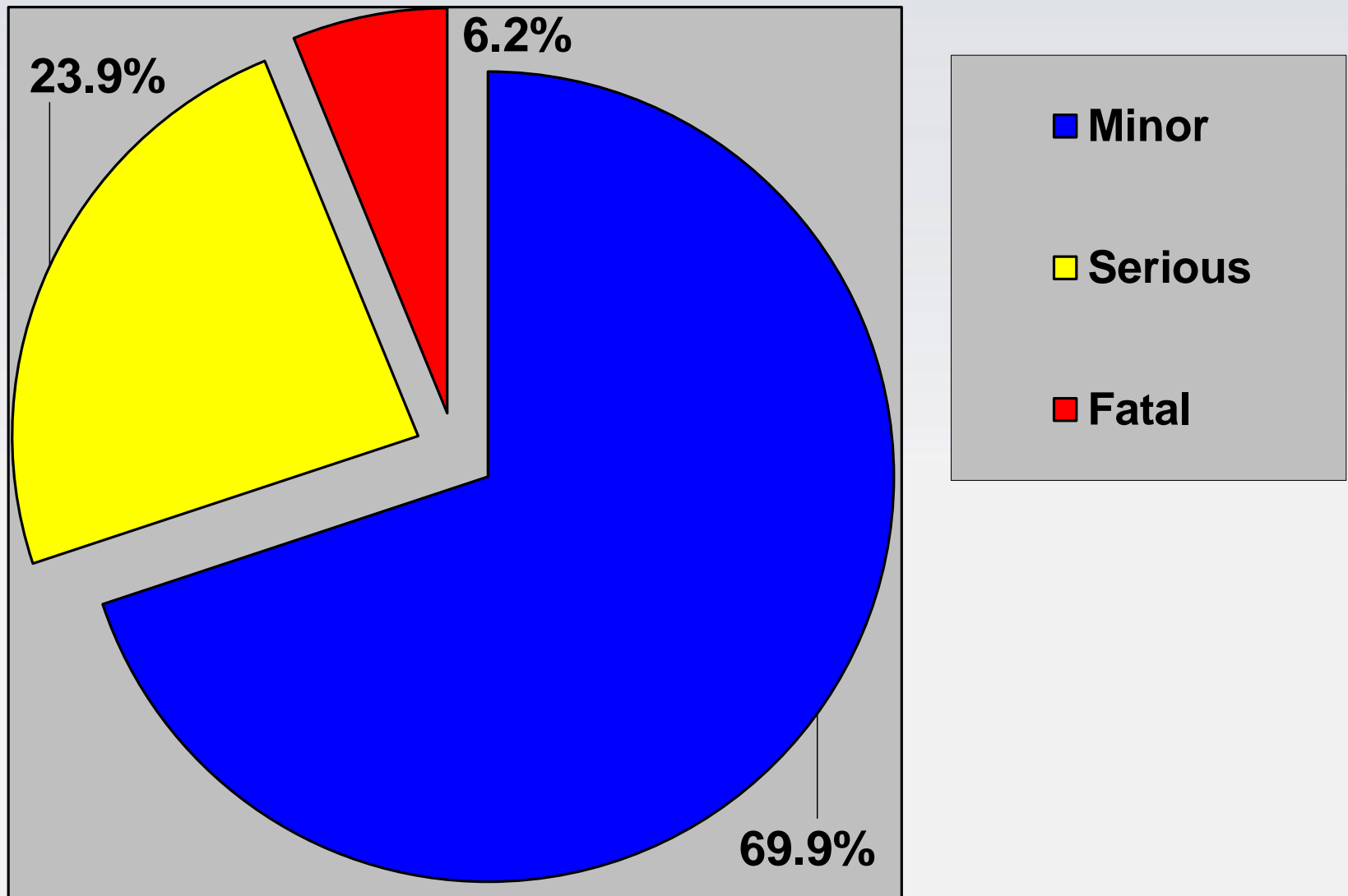
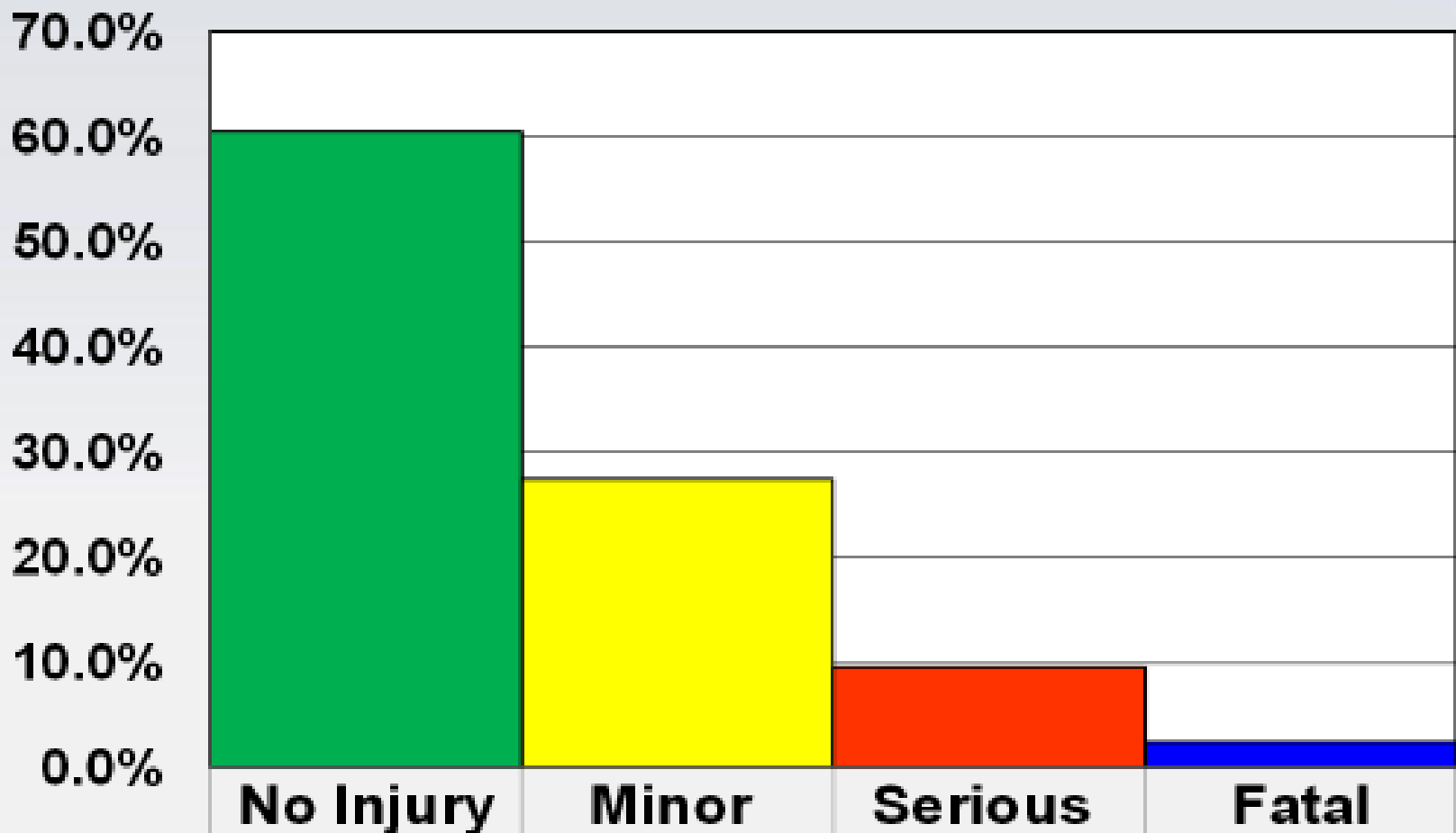


FIGURE 9. INJURY LEVELS BY PERCENTAGE FOR 1981 – 2020

Oct. 2021

Injury Risk per 100 Explosions 1980 - 2019



■ % Injury / 100 Explosions

60.5%

27.5%

9.5%

2.5%

FIGURE 10. INJURY RISK PER 100 EXPLOSIONS FOR 1981 – 2019 Sep. 2020

Injury Risk per 100 Explosions 1980 - 2020

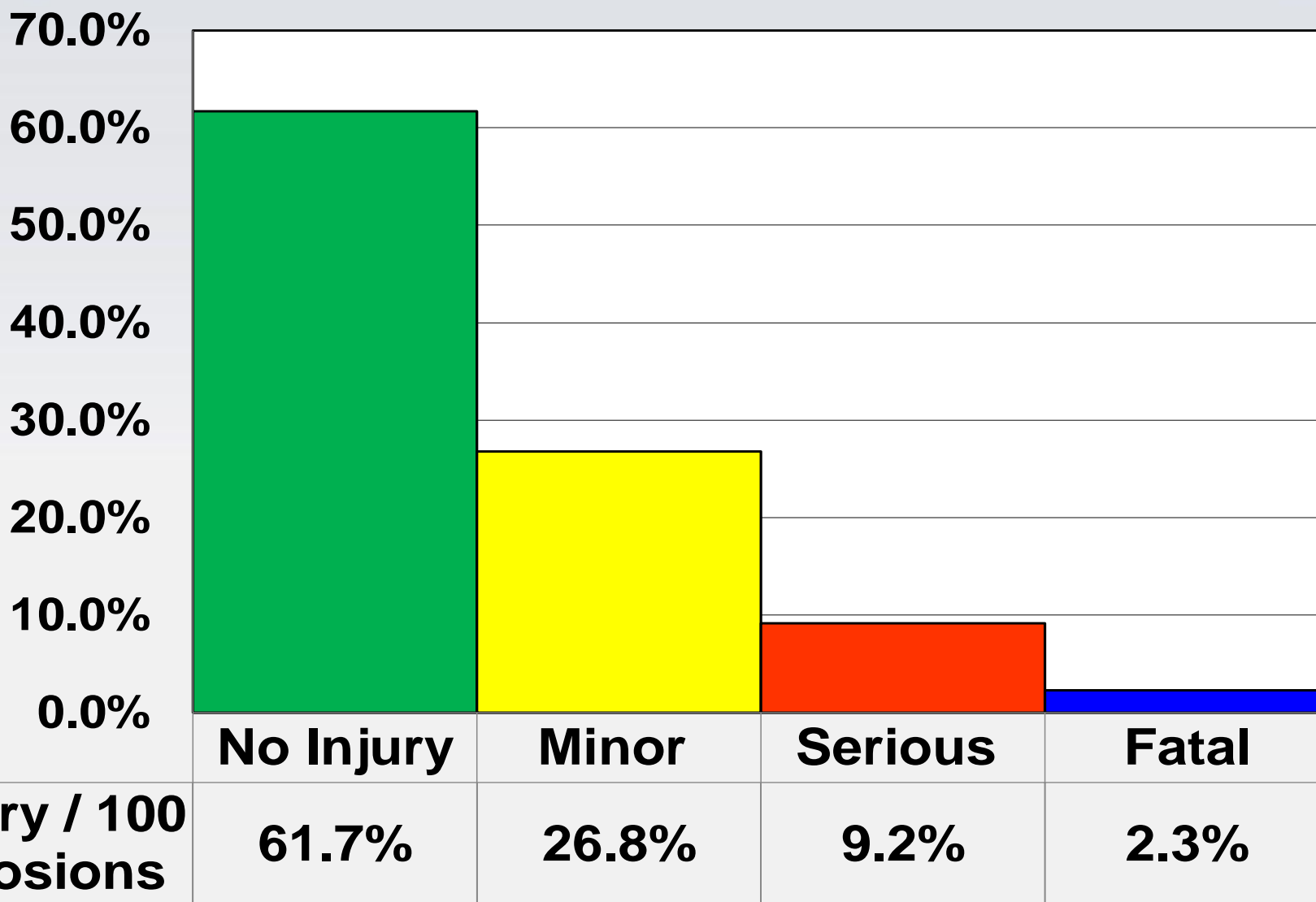


FIGURE 10. INJURY RISK PER 100 EXPLOSIONS FOR 1981 – 2020

Oct. 2021

Fatalities from Explosions 1981 to 2020

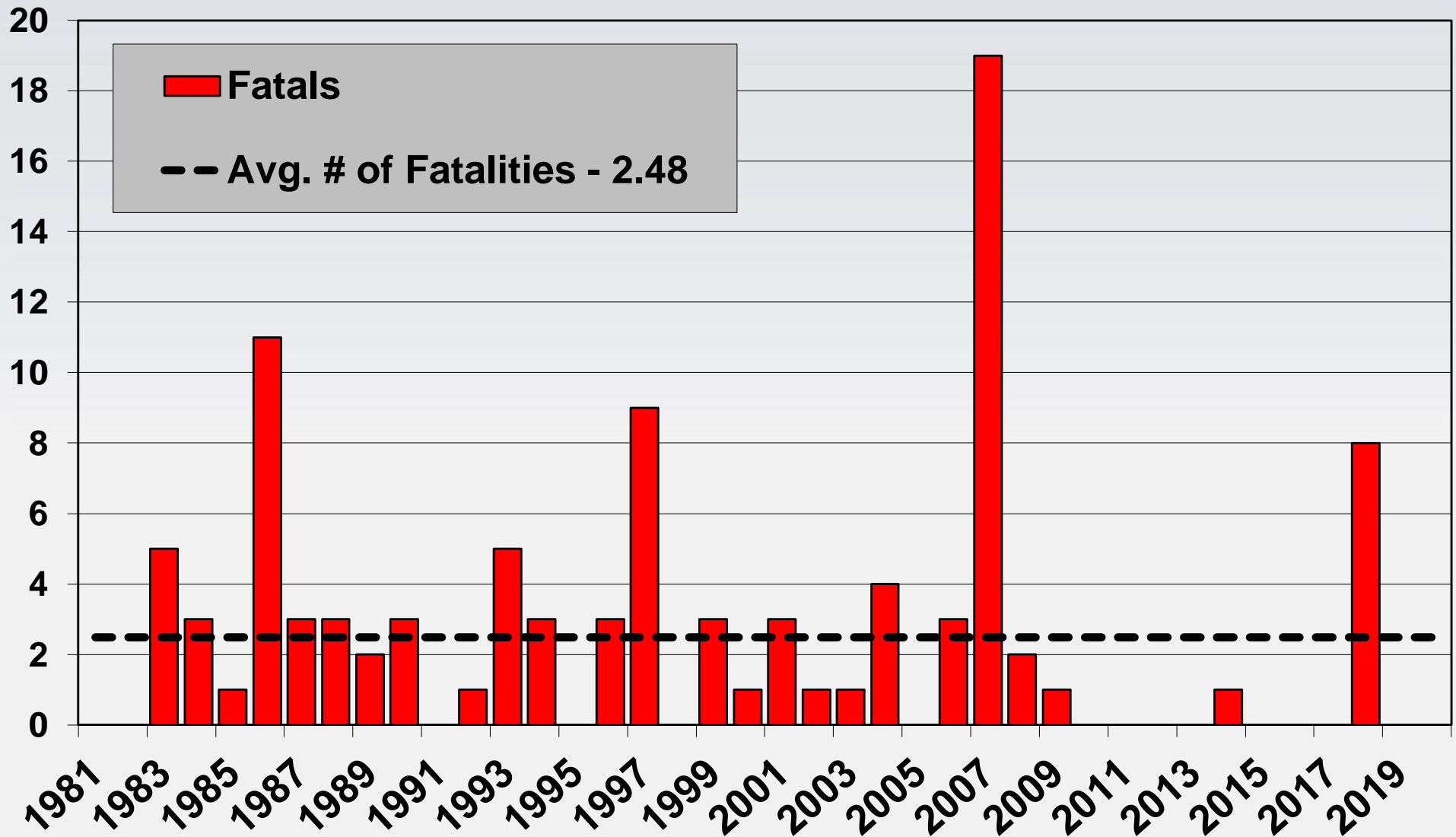


FIGURE 11. FATALITIES FROM EXPLOSIONS FOR 1981 – 2020

Oct. 2021



Average # of Injuries / Year from Explosions 2001-2015 & 2016-2020

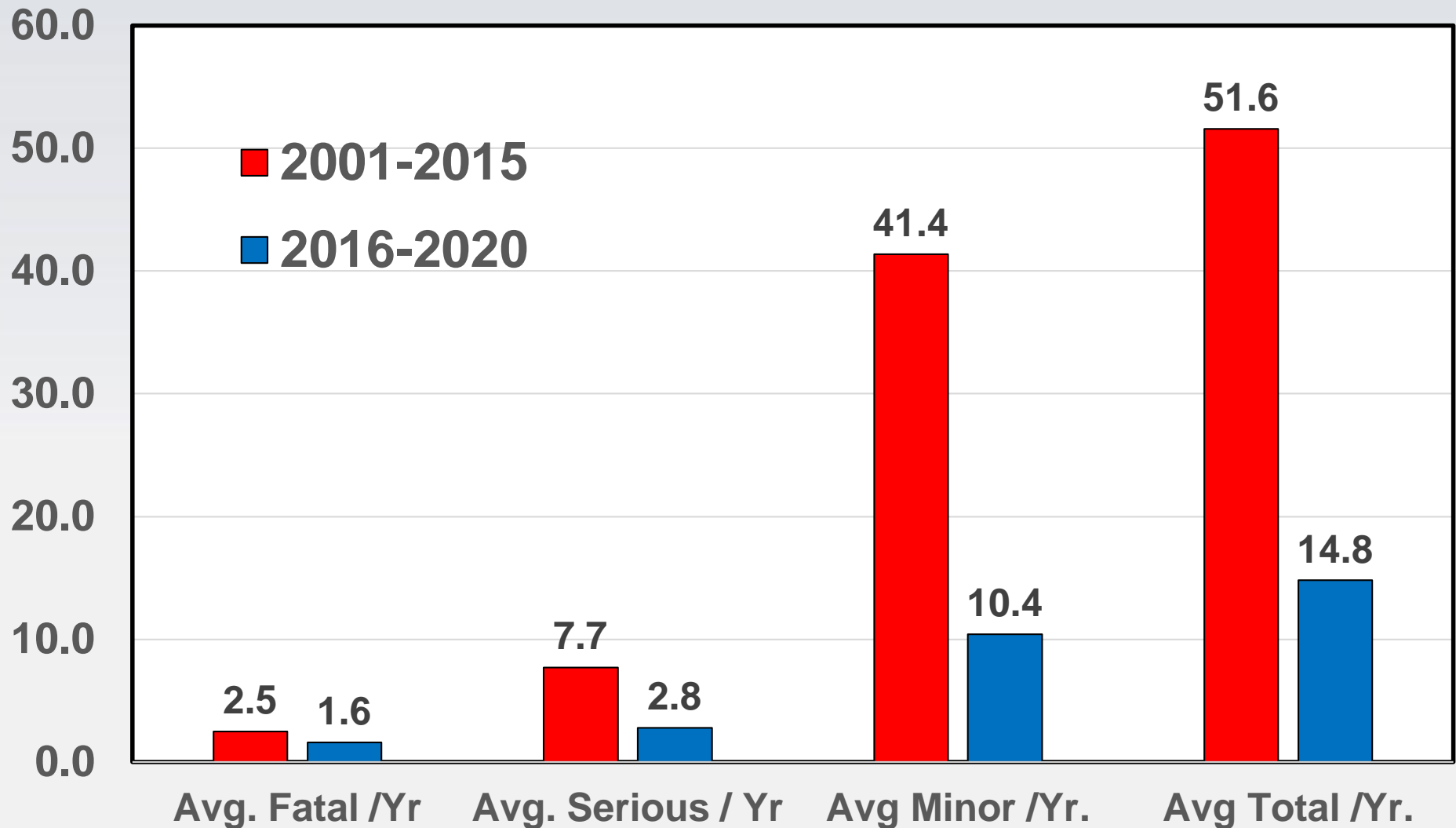
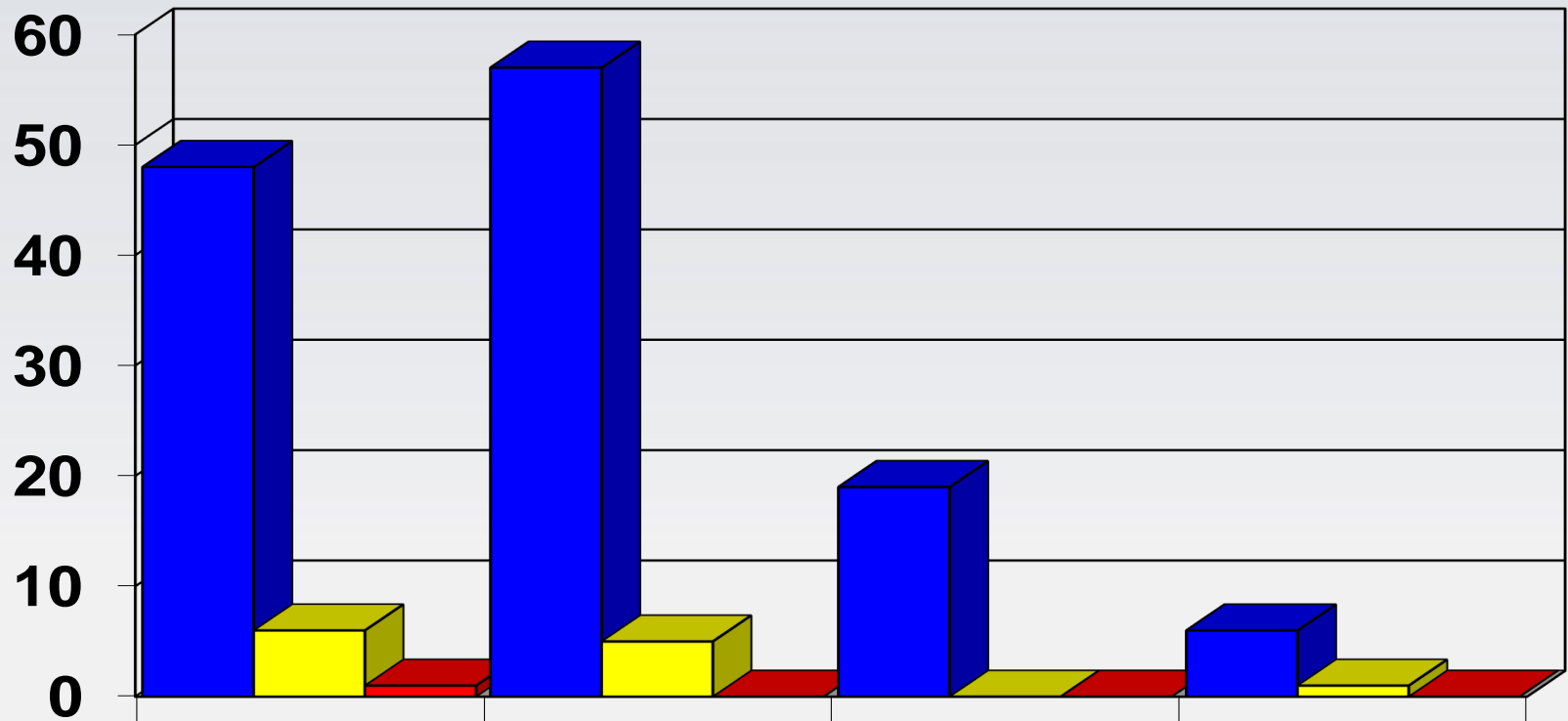


FIGURE 12. AVG. # INJURIES / YR. FOR 2001-2015 & 2016-2020

Oct. 2021

Force Level Incidents by Operation – 2020



	Melting	Casting	Transfer	Other
Force 1	48	57	19	6
Force 2	6	5	0	1
Force 3	1	0	0	0

FIGURE 13. FORCE LEVEL INCIDENTS BY OPERATION FOR 2020 Oct. 2021

Force Level Explosions by Operation 1980 to 2020

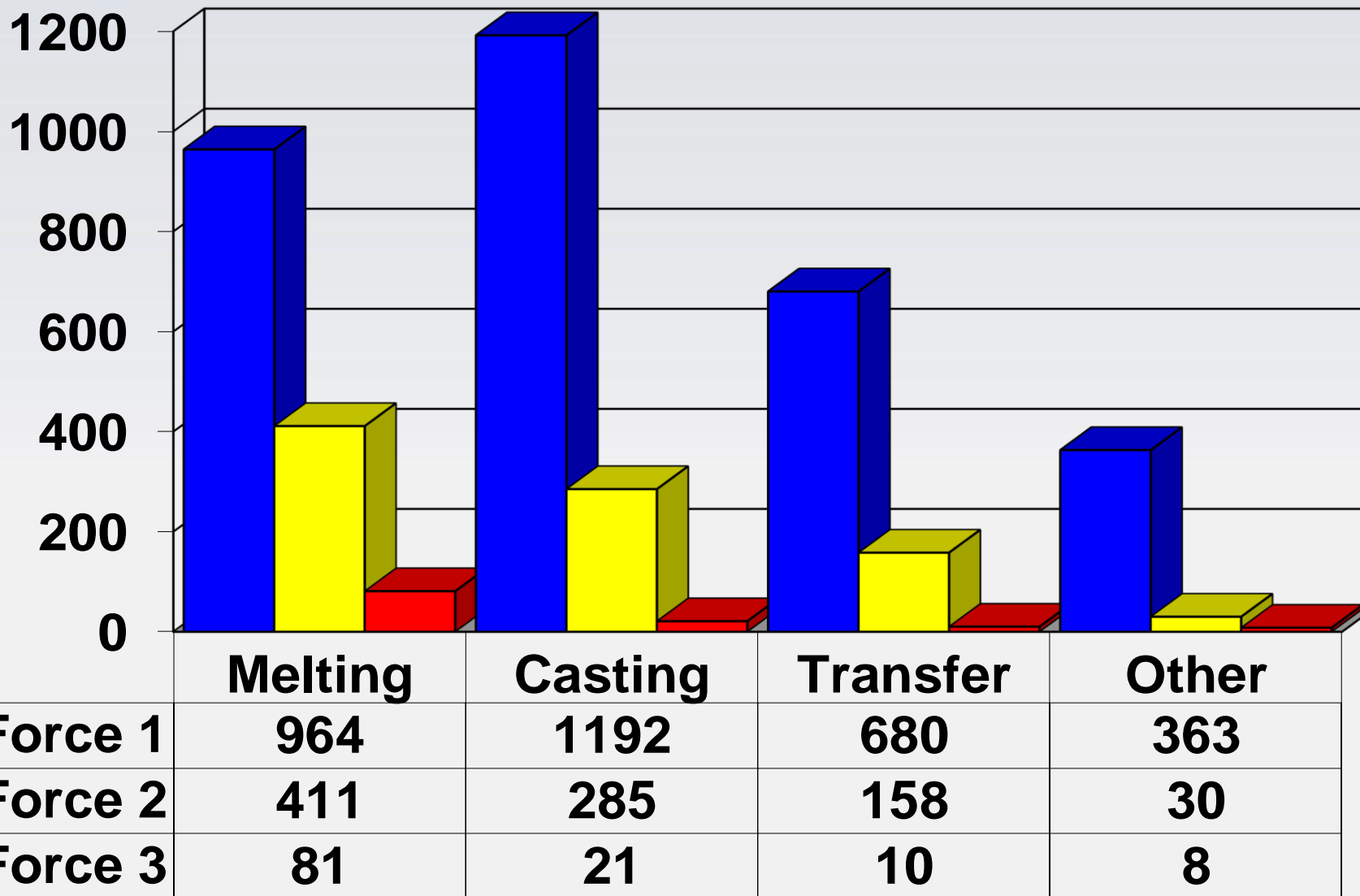


FIGURE 14. FORCE LEVEL EXPLOSIONS BY OPERATION 1980 – 2020 Oct. 2021



Melting Injuries and Incidents 1990 to 2020 (Total 334 Injuries)

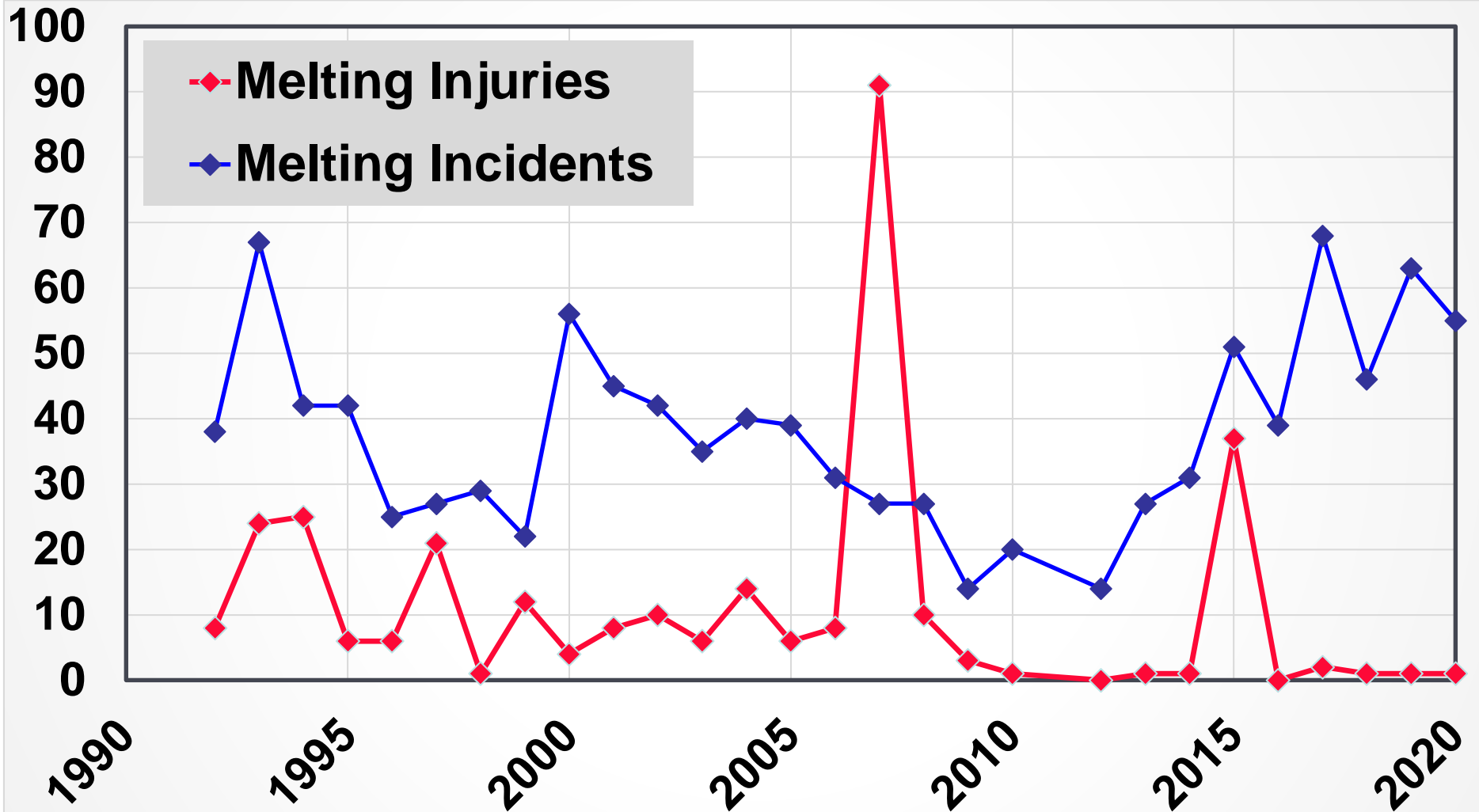


FIGURE 15. MELTING INJURIES AND INCIDENTS FOR 1990 – 2019 Oct. 2021

Melting Injuries per Incidents 1990 to 2020

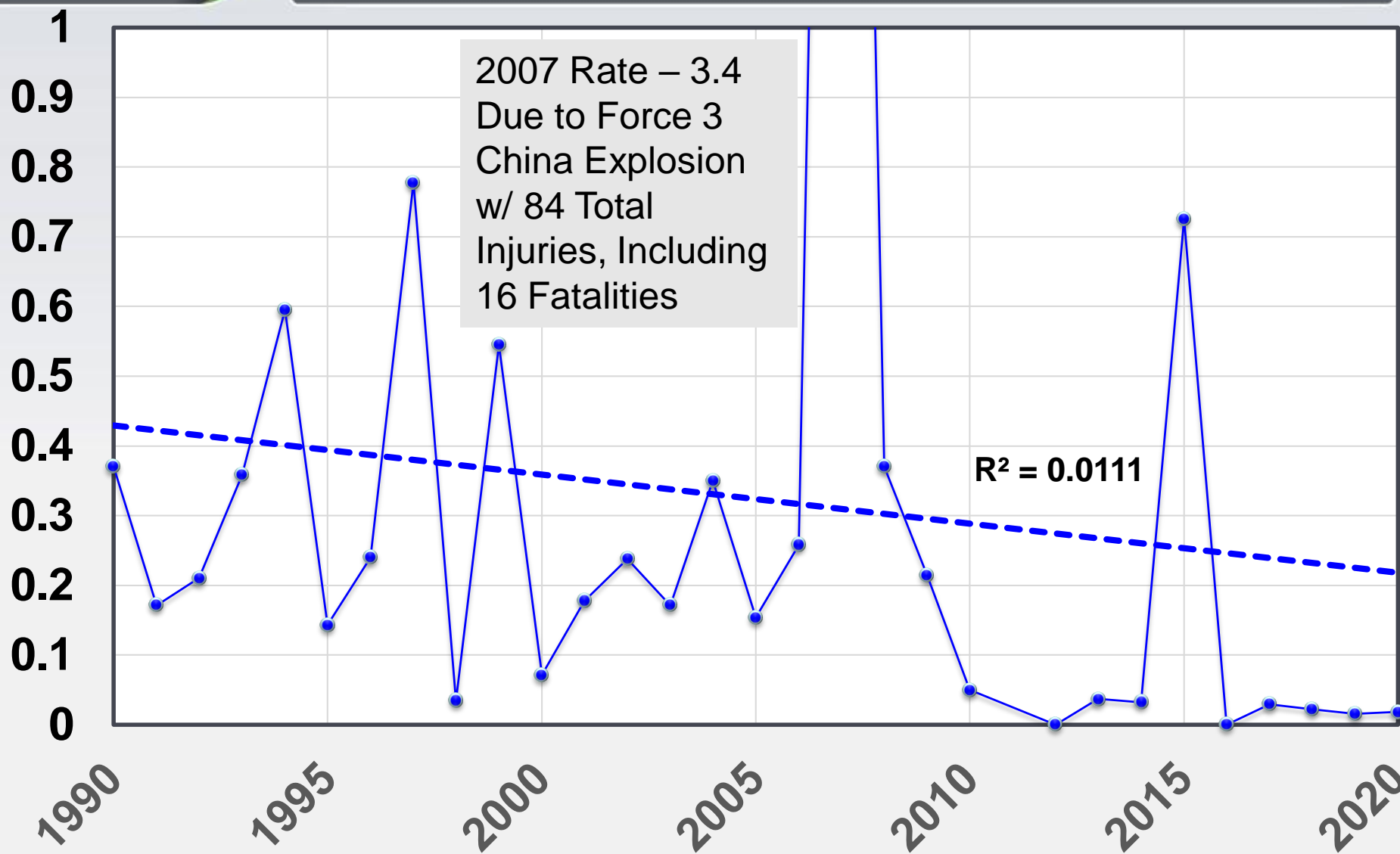


FIGURE 16. MELTING INJURIES PER INCIDENTS FOR 1990 – 2020 Oct. 2021

Casting Injuries and Incidents 1990 to 2020 (Total 340 Injuries)

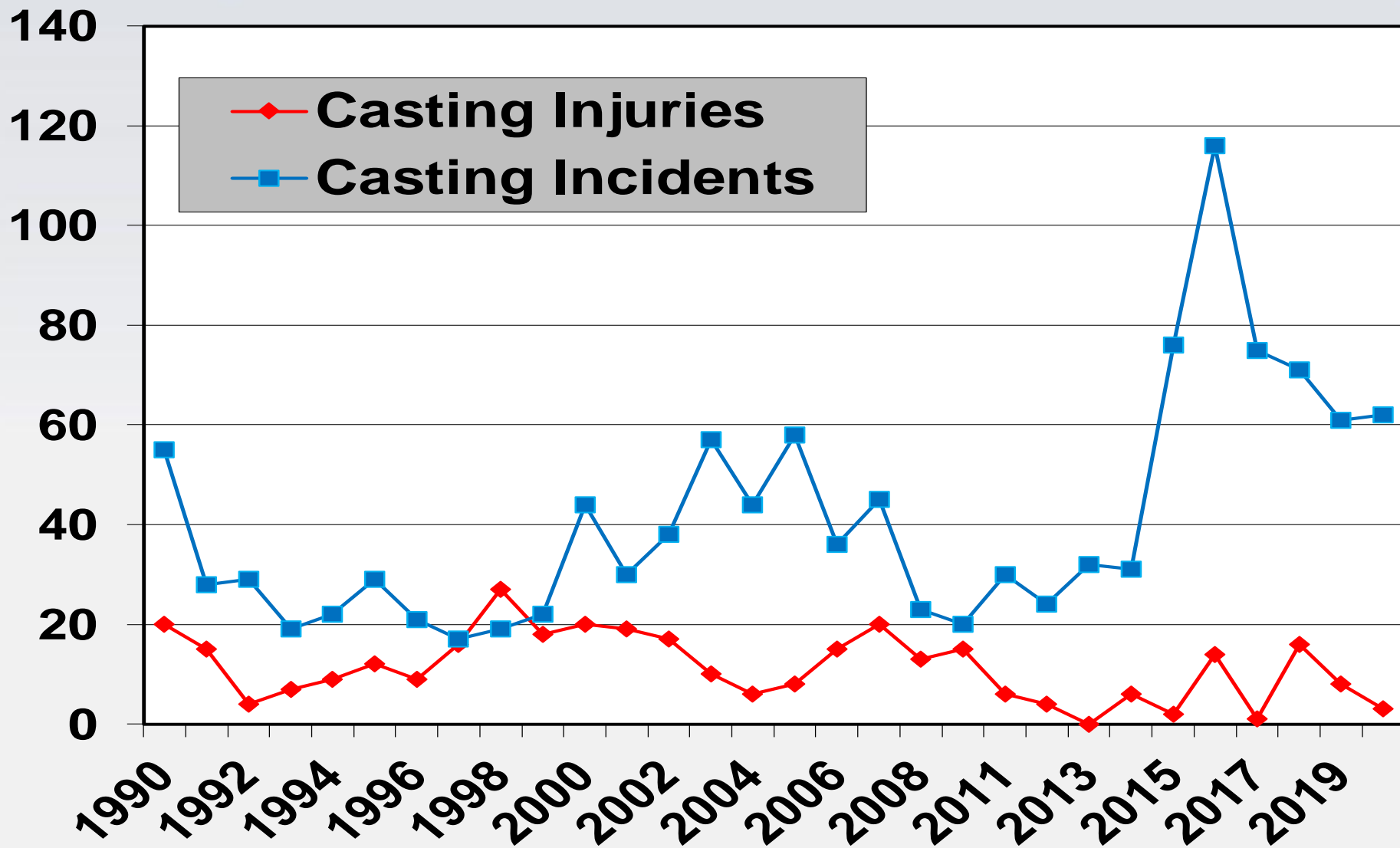


FIGURE 17. CASTING INJURIES AND INCIDENTS FOR 1990 – 2020 Oct. 2021

Casting Injuries per Incidents 1990 to 2020

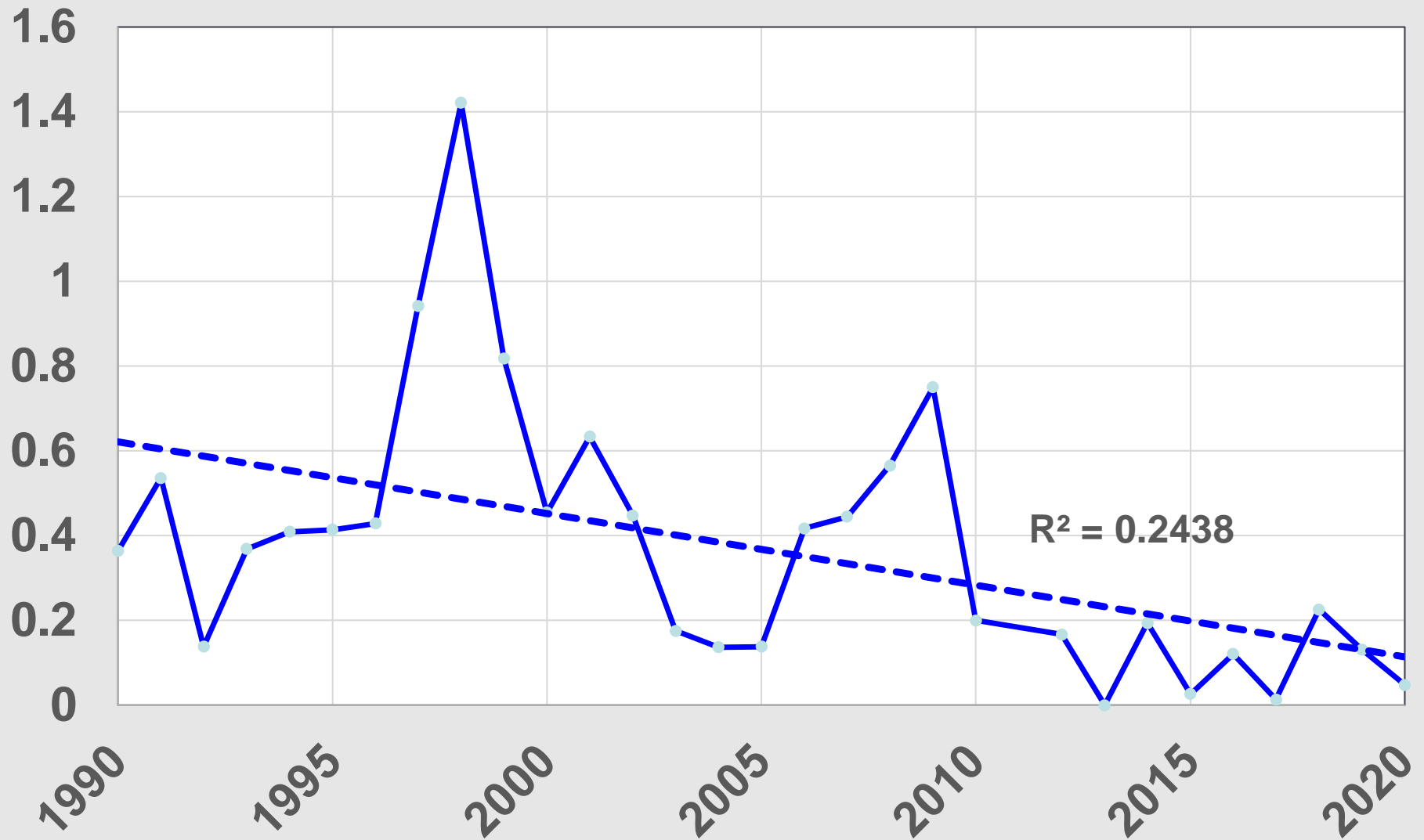


FIGURE 18. CASTING INJURIES PER INCIDENTS FOR 1990 – 2020 Oct. 2021

Transfer Injuries and Incidents 1990 to 2020 (Total 245 Injuries)

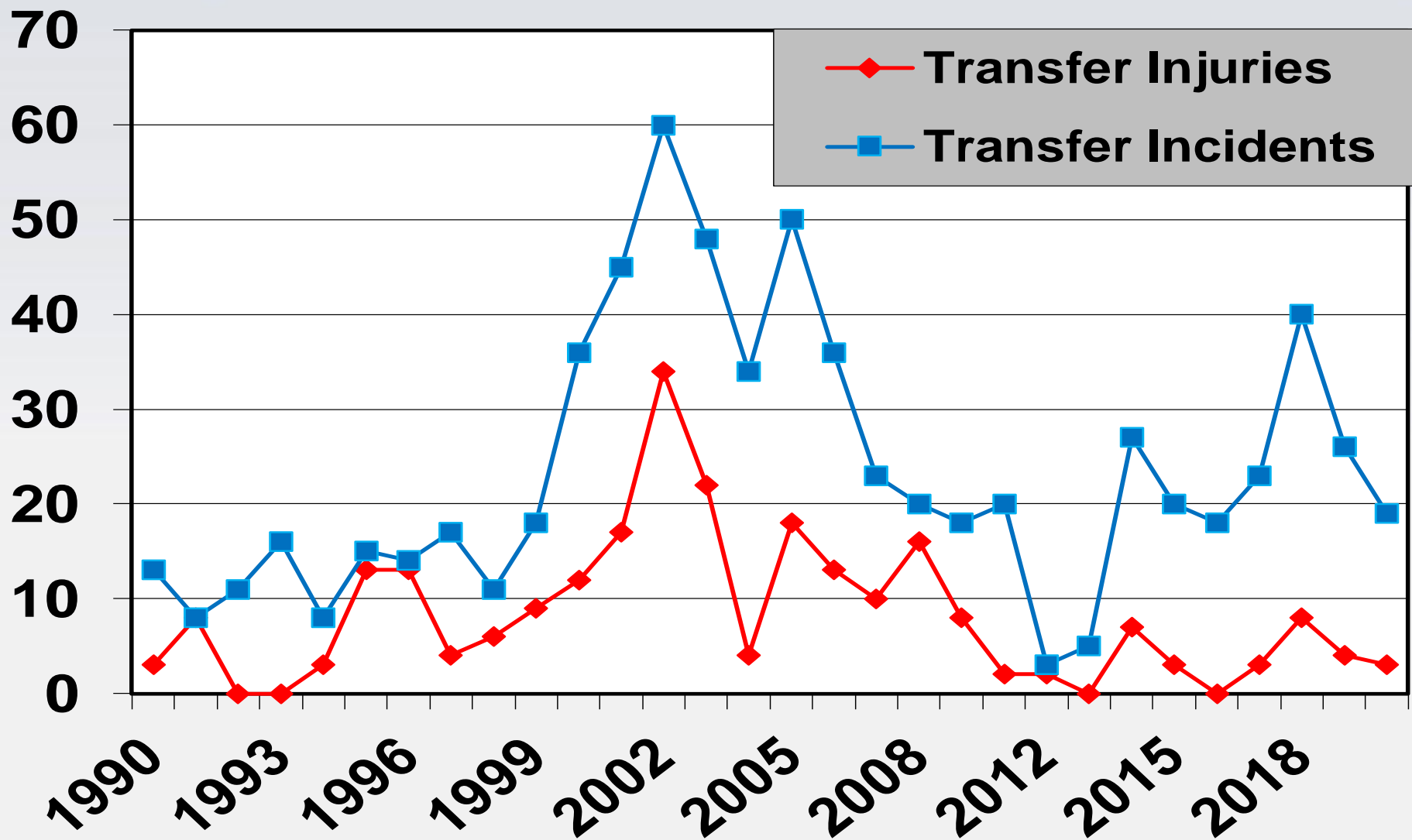


FIGURE 19. TRANSFER INJURIES AND INCIDENTS FOR 1990–2020 Oct. 2021

Transfer Injuries per Incidents 1990 to 2020

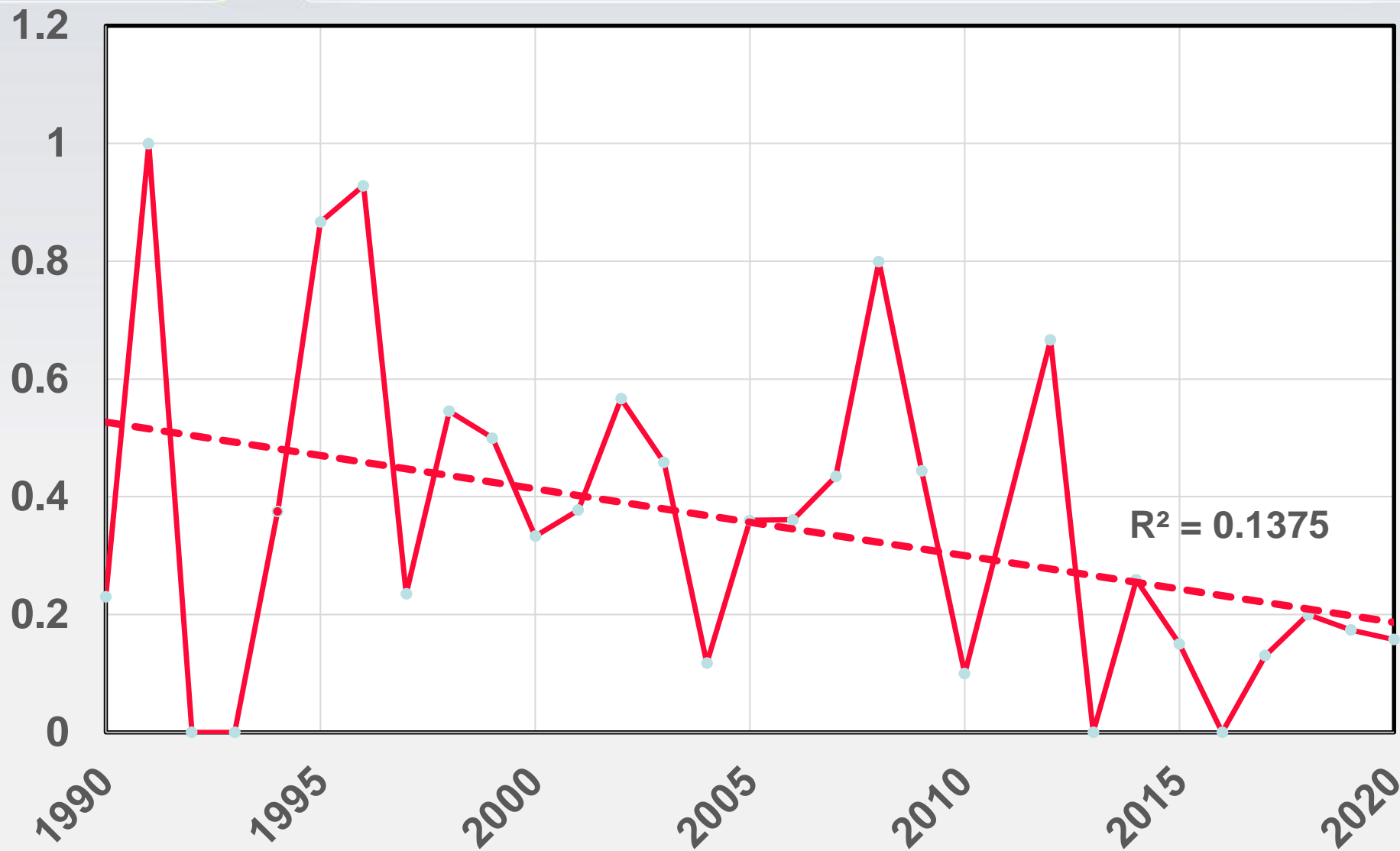


FIGURE 20. TRANSFER INJURIES PER INCIDENTS FOR 1990–2020 Oct. 2021

55 Melting Explosions - 2020

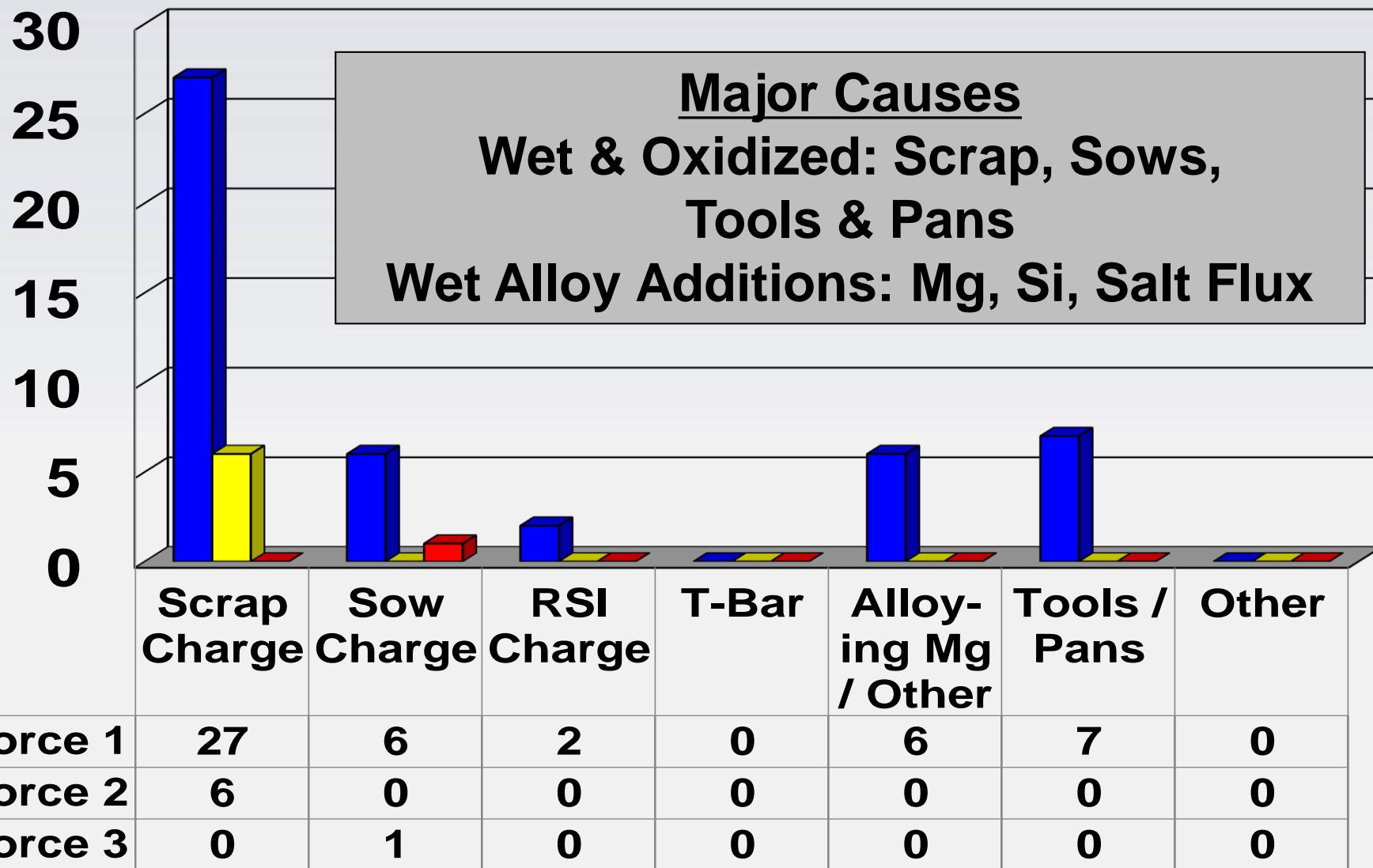


FIGURE 21. MELTING EXPLOSIONS BY CAUSE FOR 2020

Oct. 2021



Melting Explosions - Charge Material Involved 1980 - 2020

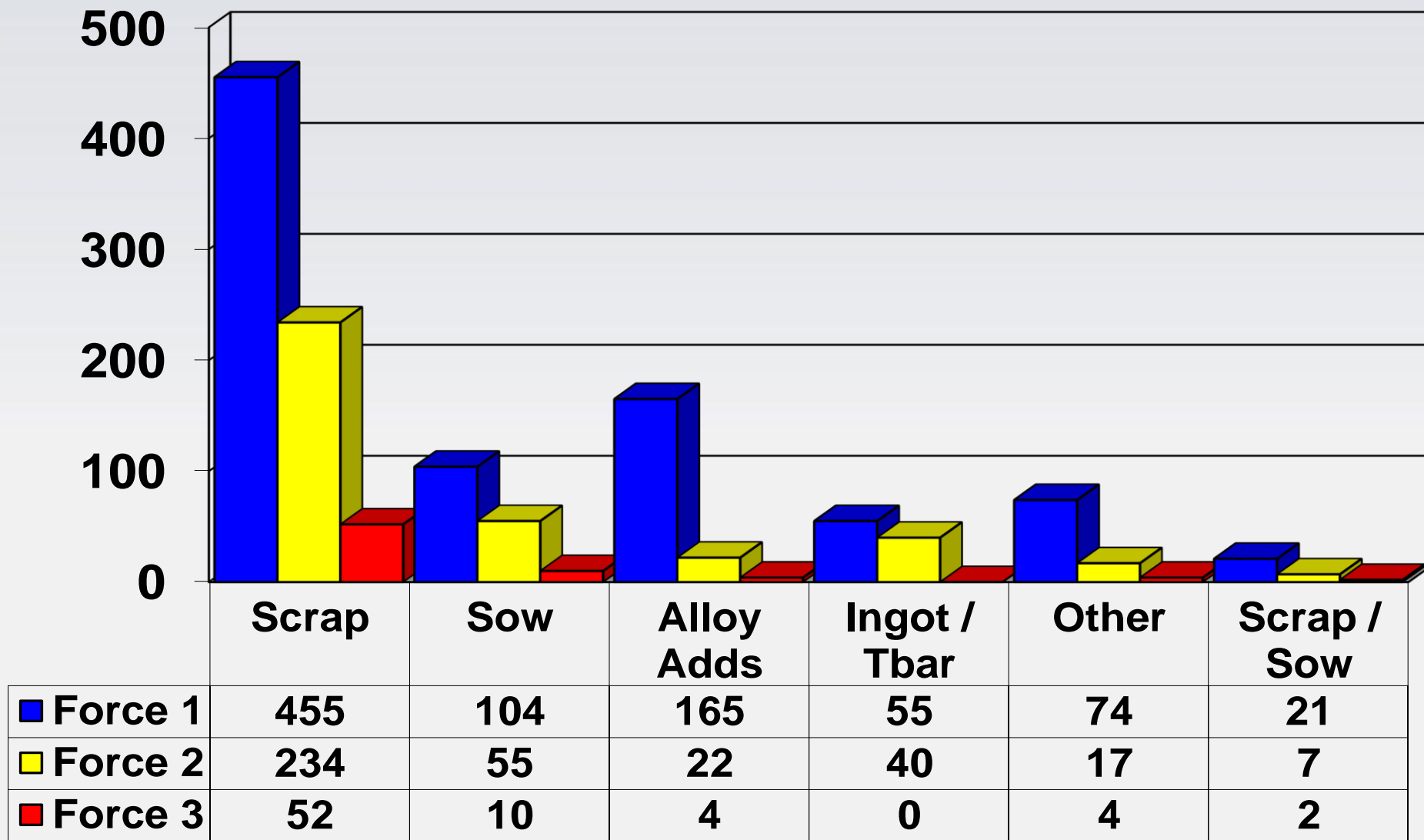
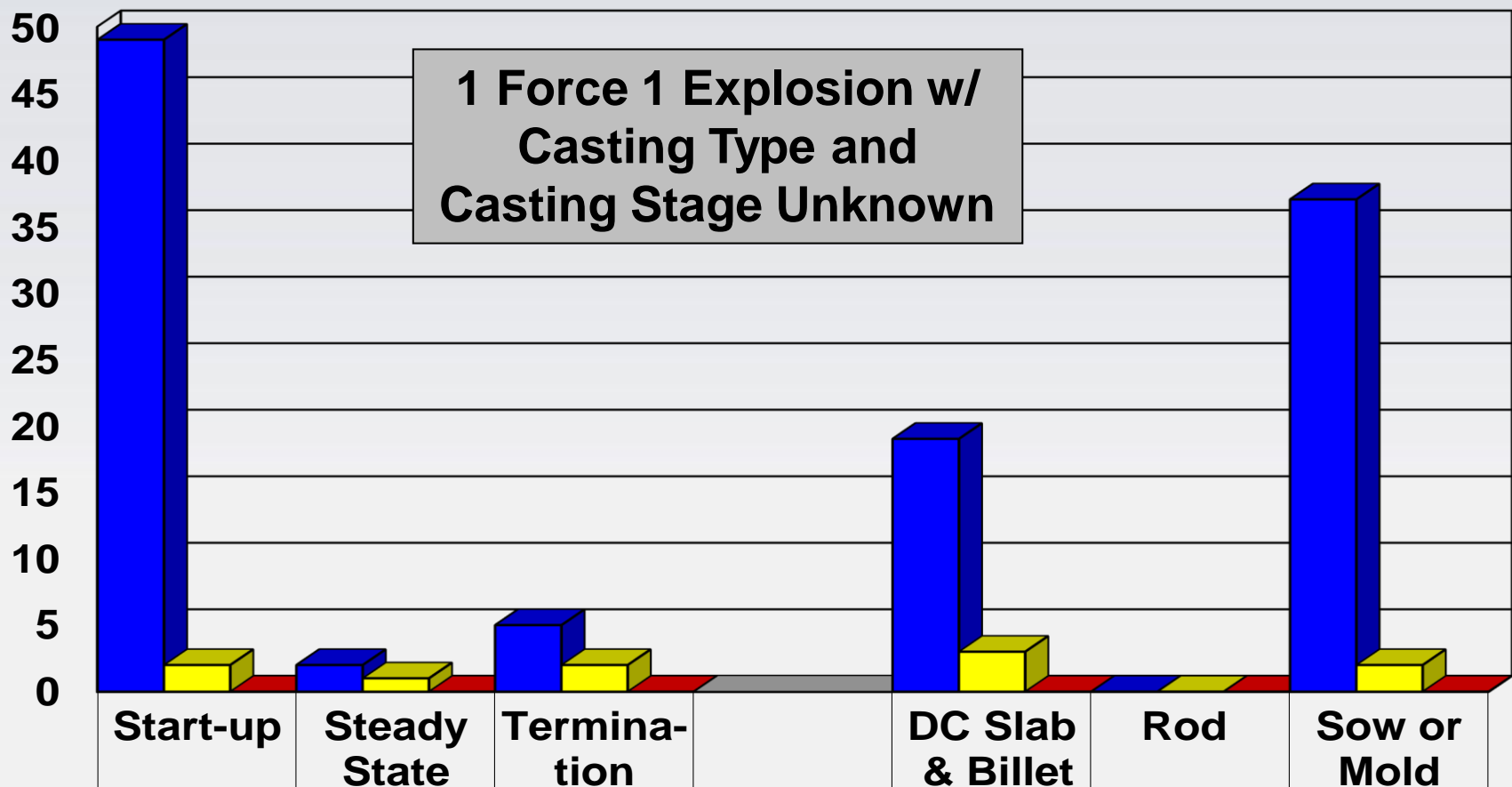


FIGURE 22. MELTING EXPLOSIONS BY CHARGE MATERIAL 1980 – 2020 Oct. 2021

62 Casting Explosions - 2020



	Start-up	Steady State	Termination		DC Slab & Billet	Rod	Sow or Mold
Force 1	49	2	5		19	0	37
Force 2	2	1	2		3	0	2
Force 3	0	0	0		0	0	0

FIGURE 23. CASTING EXPLOSIONS FOR 2020

Oct. 2021

DC/HDC/EMC Explosions by Cast Segment 1980 to 2020

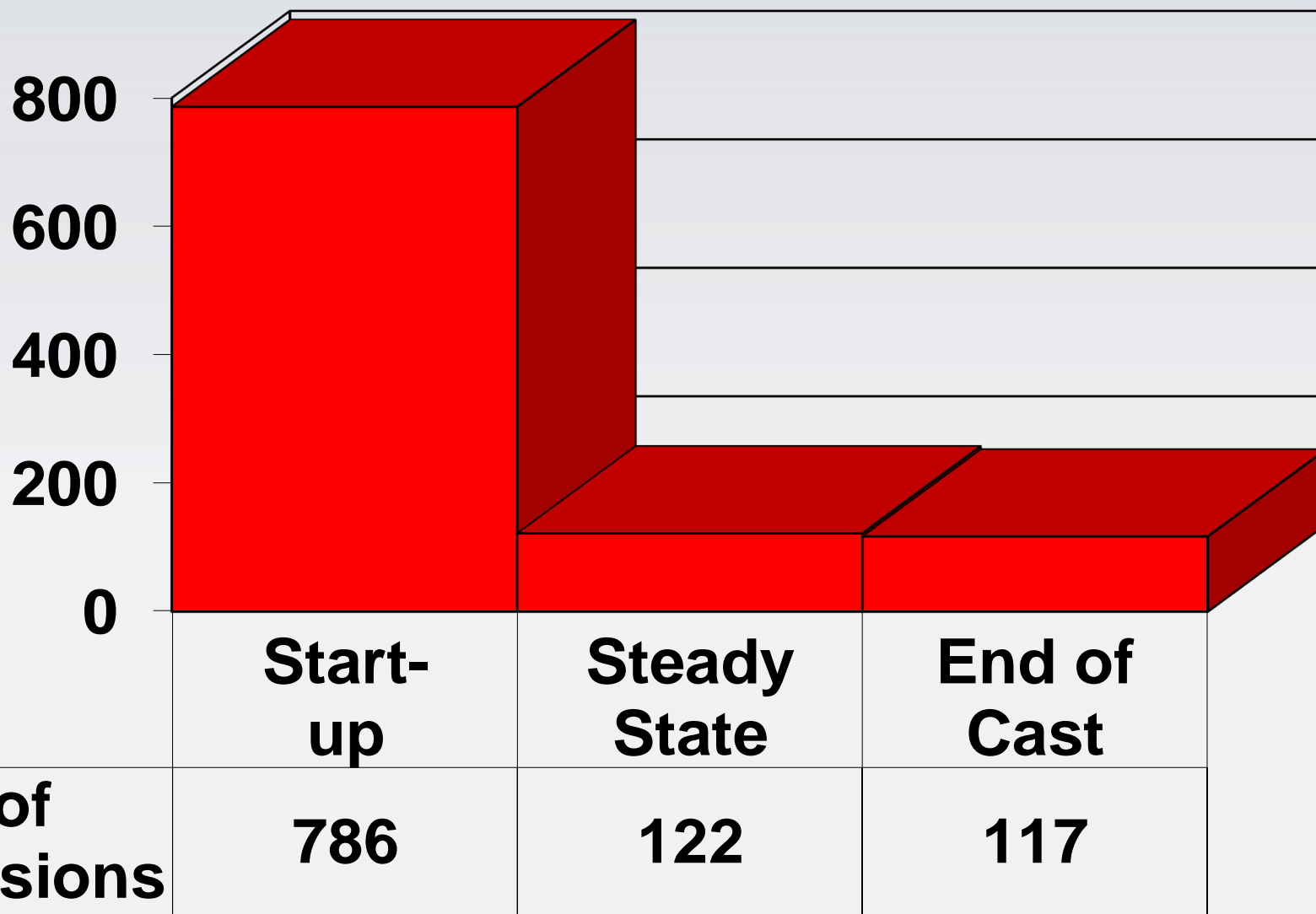


FIGURE 24. CASTING EXPLOSIONS by CAST SEGMENT 1981 – 2020 Oct. 2021

Major Causes of 61 Casting Incidents – 2020

- **DC Start-up Issues: Wet Starting Blocks / Wet Equipment / Launder, Equipment Set-up & Failure, Hang-ups, Bleed-outs, Mold Water Issues, SOP Not Adapted or Not Followed**
- **DC Steady State Issues: Equipment Failure / Maintenance, Wet/Rusty Equipment**
- **DC Termination Issues: Wet Rusty Drain Pan, Platen Not Stopping / Ingot Head Under Water**
- **Sow / Mold Casting Issues: Wet / Cracked Molds, Wet Equipment / Tools**



MAJOR CAUSES OF CASTING EXPLOSIONS 2015 thru 2020

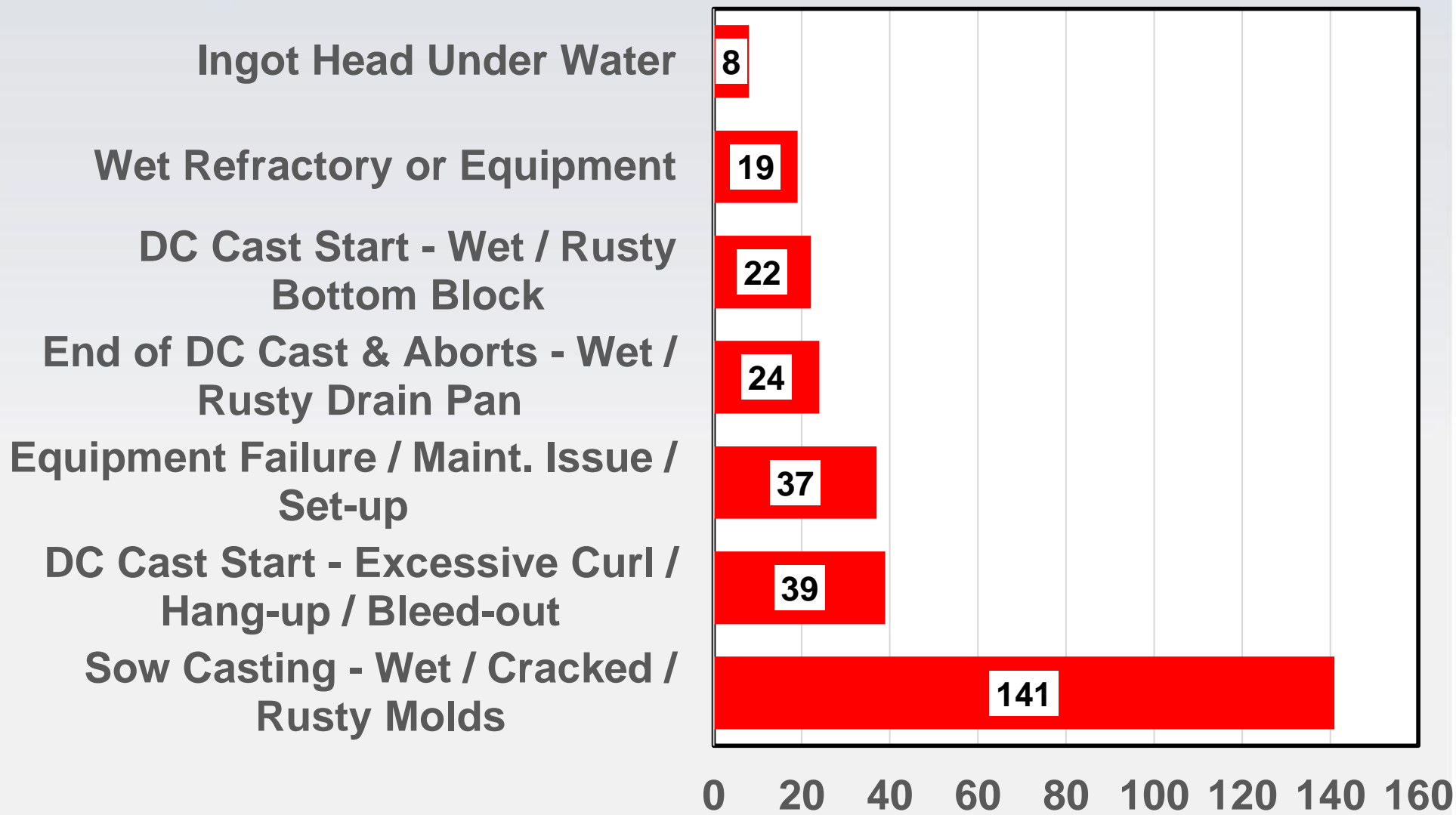


FIGURE 26. CASTING EXPLOSIONS by MAJOR CAUSES 2015–2020 Oct. 2021



MAJOR CAUSES OF FORCE 2 & 3 CASTING EXPLOSIONS - 2015 thru 2020

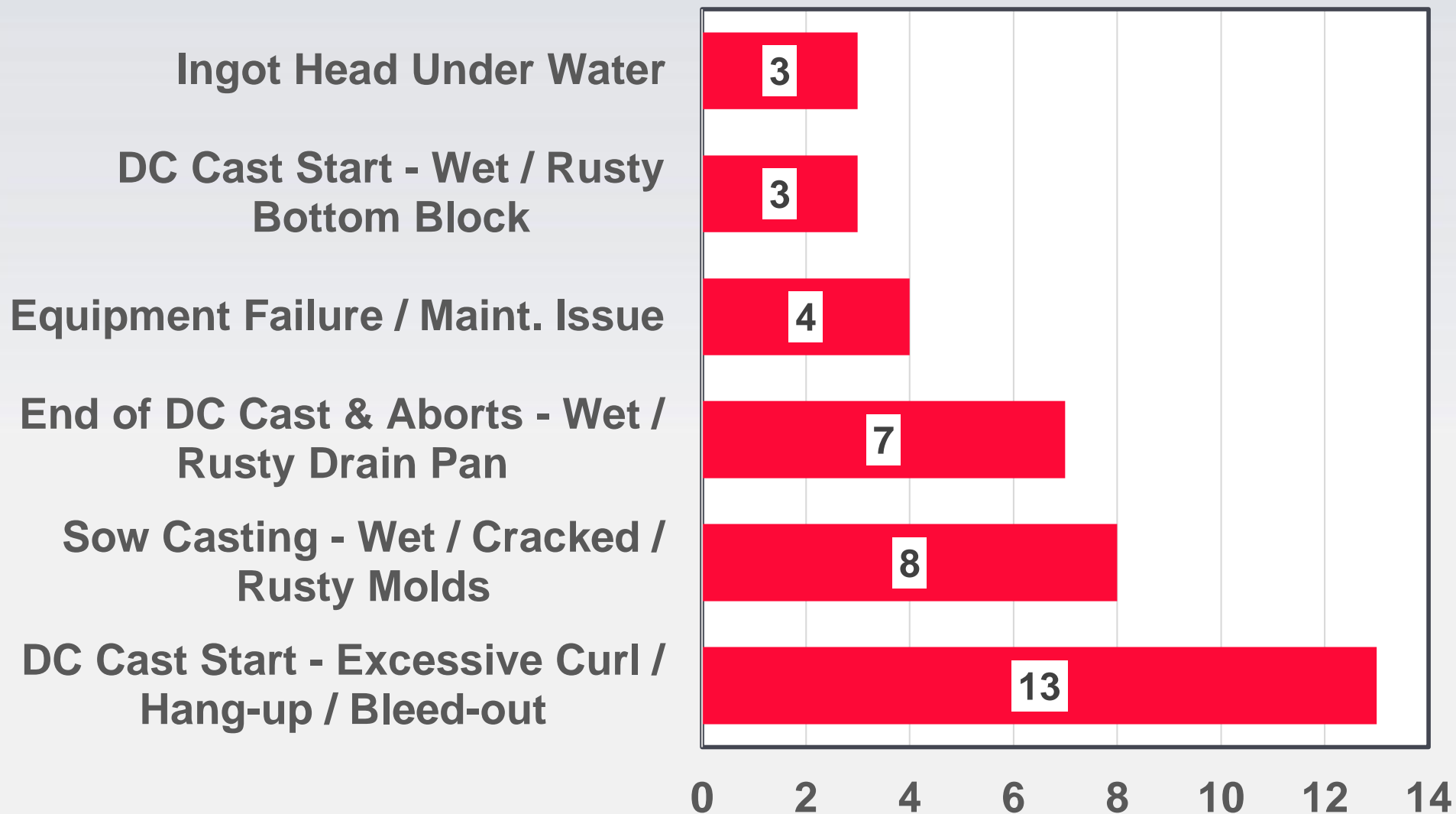
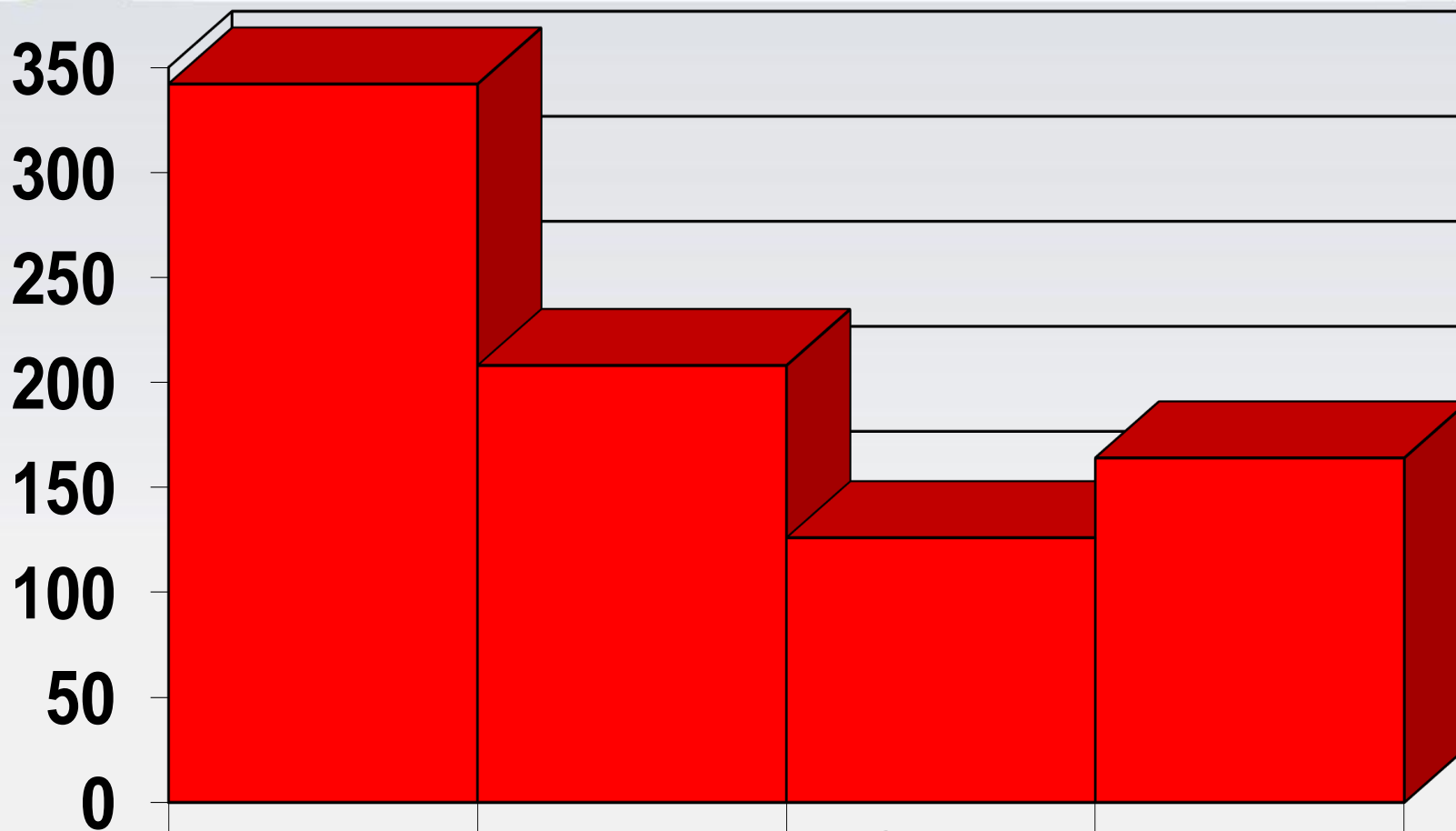


FIGURE 27. CASTING EXPLOSIONS by MAJOR CAUSES 2015–2020 Oct. 2021

Major Causes of 19 Transfer Explosions - 2020

- 7- Wet Transfer Equipment**
- 6 - Wet / Rusty Drain Pan or Mold**
- 3 – Wet Hand or Furnace Tools**
- 2 – Wet Refractory**
- 1 – Bath Overflow Wet Floor**

Transfer Explosions by Equipment – Total 840 1980 to 2020



of Explosions

Drain
Pan

342

Trough

208

Cruci-
ble

126

Other

164

FIGURE 29. TRANSFER EXPLOSIONS by EQUIPMENT 1980 - 2020

Oct. 2021

MAJOR CAUSES OF TRANSFER EXPLOSIONS 2008 thru 2020 (w/o 2011)

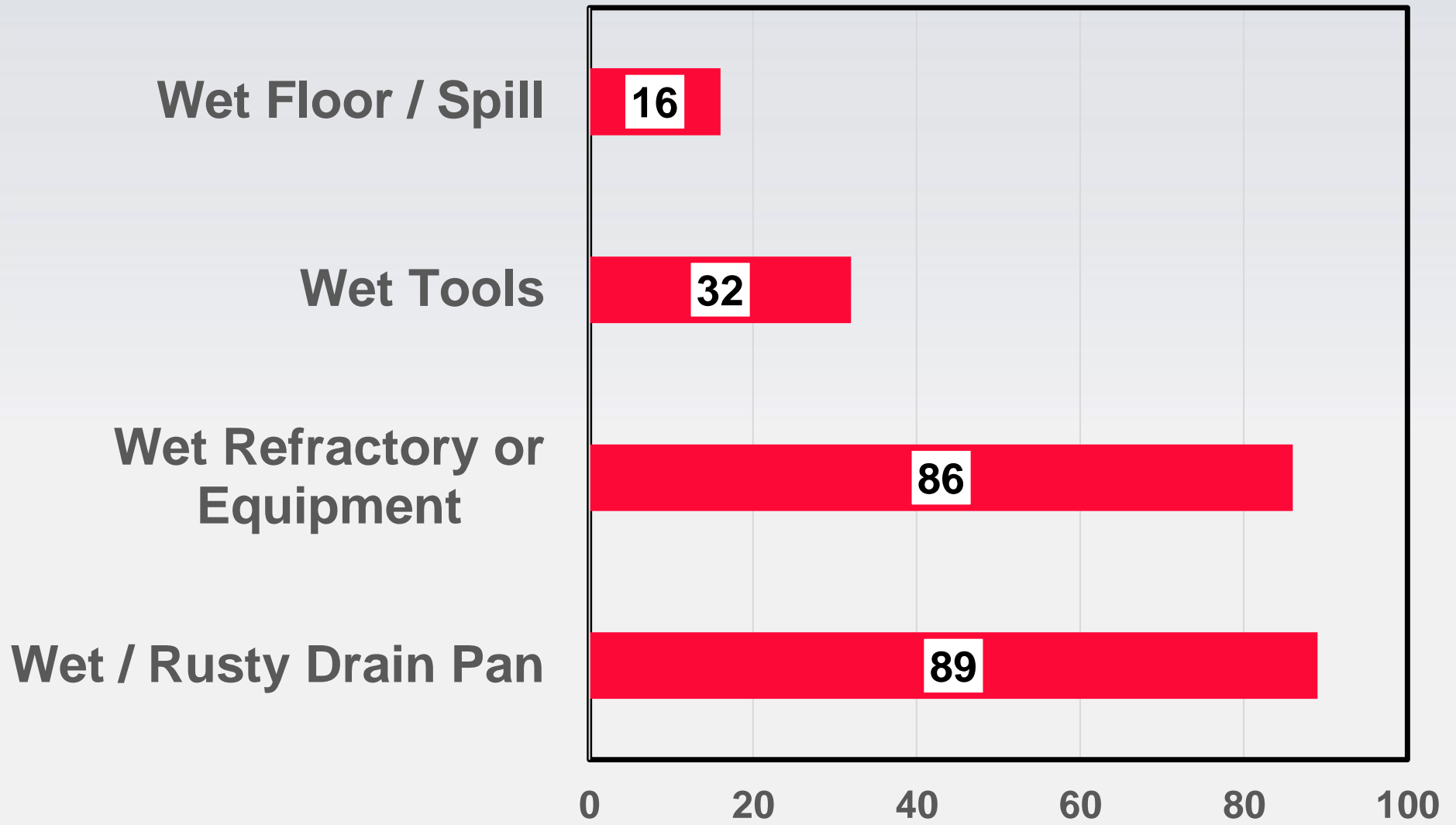


FIGURE 30. TRANSFER EXPLOSIONS - MAJOR CAUSES 2008–2020 Oct. 2021

MAJOR CAUSES OF FORCE 2 & 3 TRANSFER EXPLOSIONS - 2008 thru 2020 (w/o 2011)

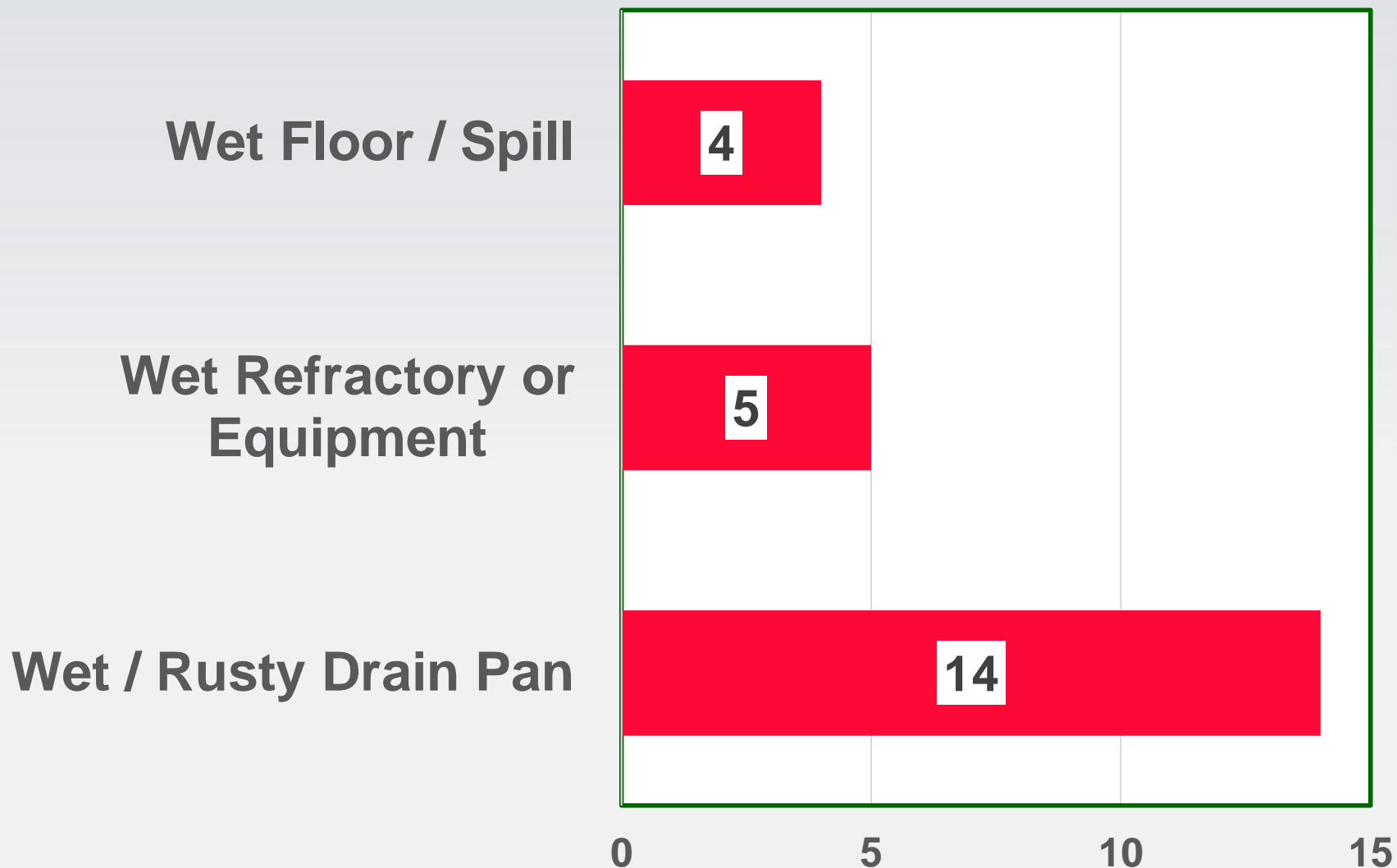
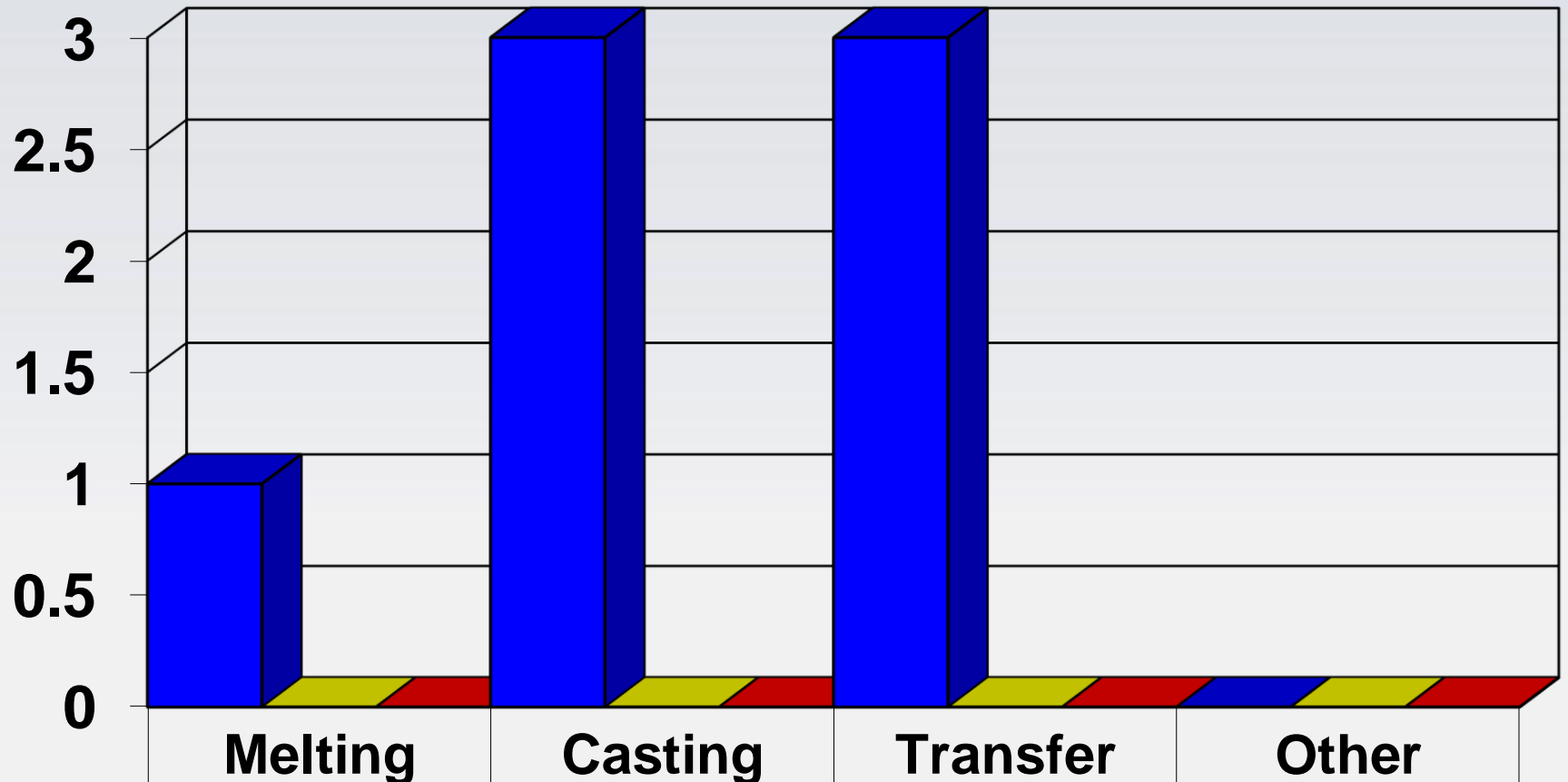


FIGURE 31. TRANSFER EXPLOSIONS - MAJOR CAUSES 2008–2020 Oct. 2021

7 Injuries by Operation - 2020

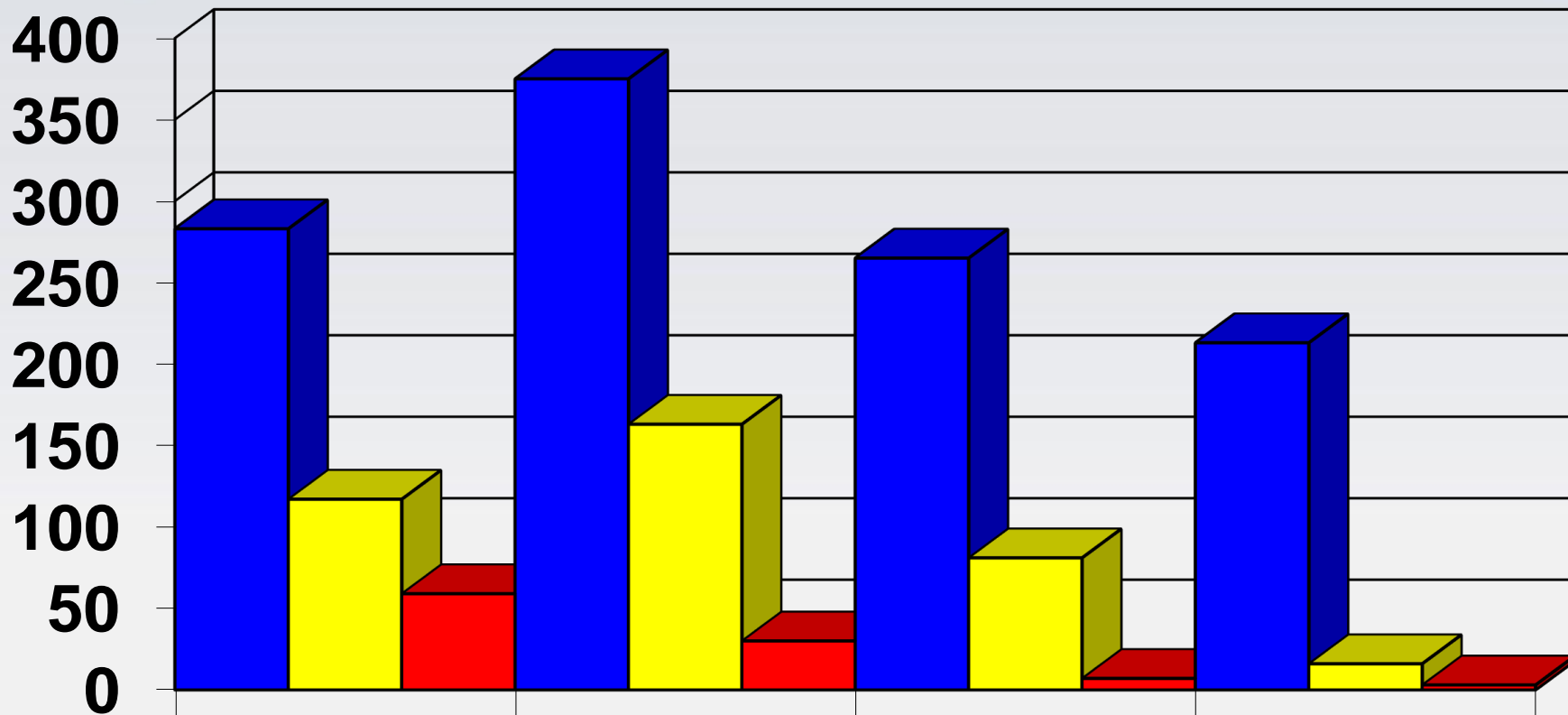


 Minor	1	3	3	0
 Serious	0	0	0	0
 Fatal	0	0	0	0

FIGURE 32. INJURIES BY OPERATION FOR 2020

Oct. 2021

1612 Injuries by Operation: 1981 – 2020



	Melting	Casting	Transfer	Other
 Minor	283	375	265	213
 Serious	117	163	81	16
 Fatal	59	30	7	3

FIGURE 33. INJURIES BY OPERATION FOR 1980 - 2020

Oct. 2021

Force Level by Process Plant - 2020

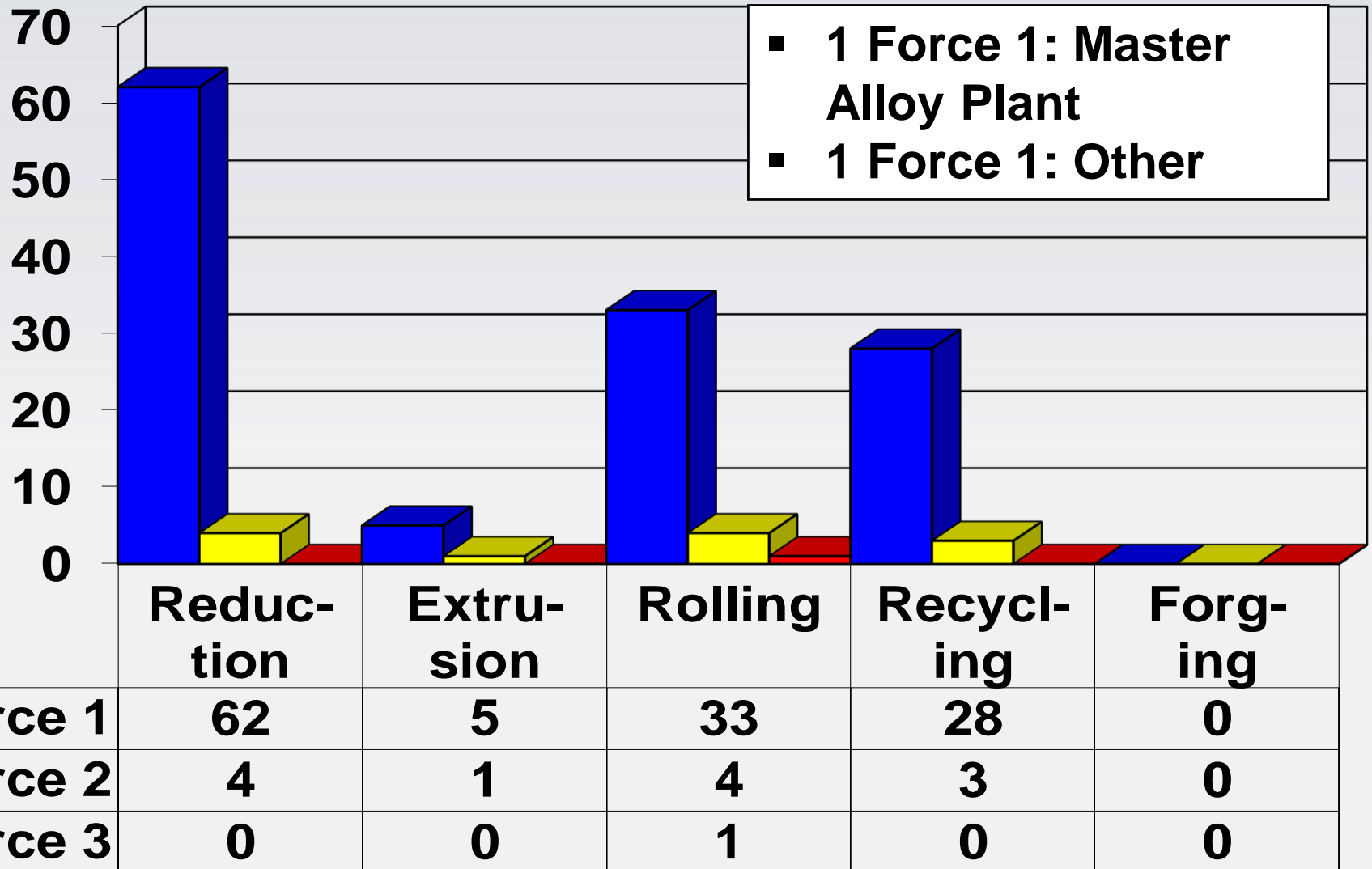


FIGURE 34. FORCE LEVEL BY PROCESS PLANT REPORTED FOR 2020 Oct. 2021

Force Level by Process Plant 1980 to 2020

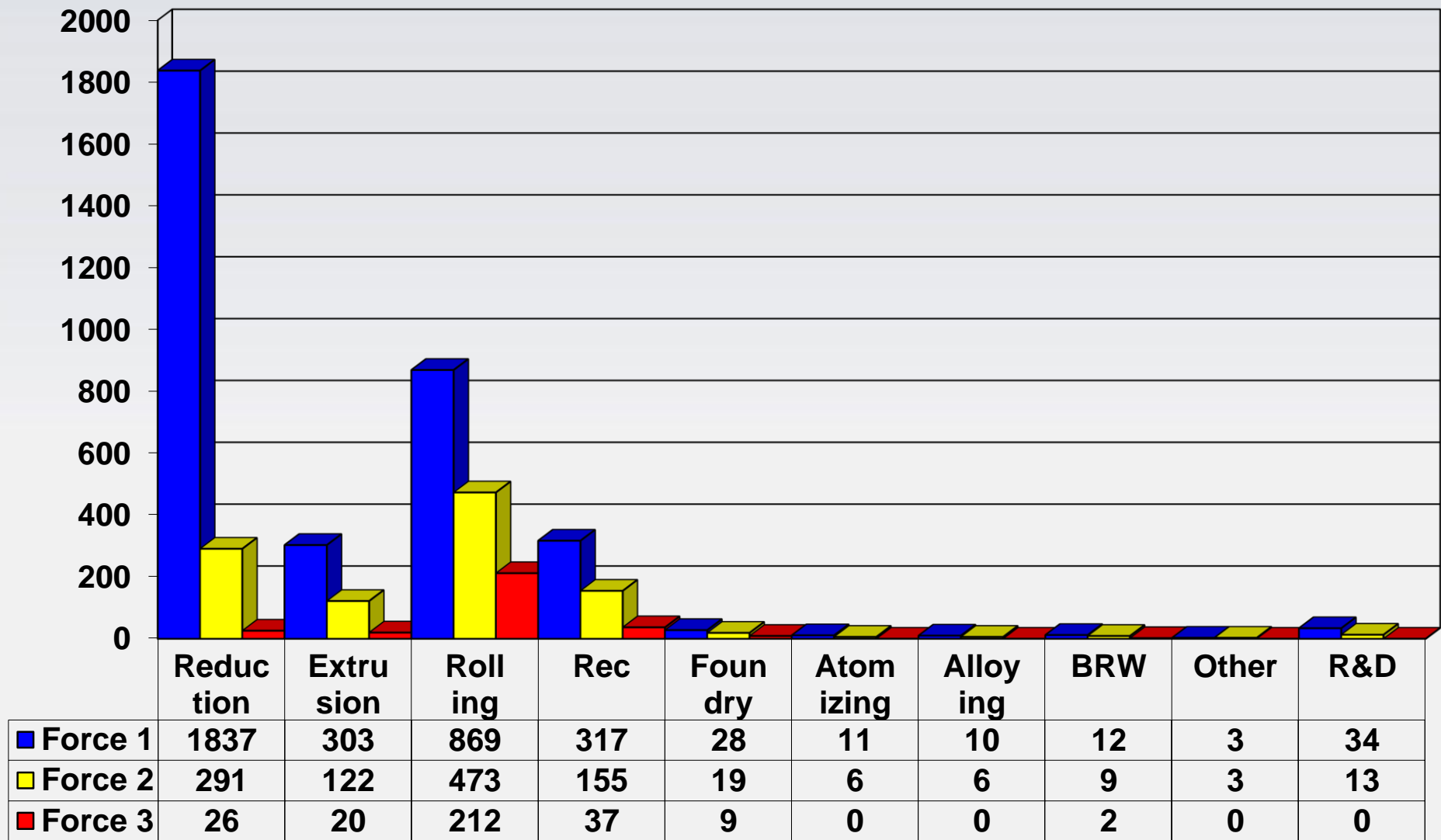


FIGURE 35. FORCE LEVEL BY PROCESS PLANT FOR 1980 - 2020 Oct. 2021

Melting Incidents	Casting Incidents
6 - Wet Charge: Scrap, Sow or Salt Flux	30 - Sow Casting - Cracked, Wet or Rusty Molds
2 - Wet Furnace Tool	2 - Start-Up – Wet Equipment 2 – Start-Up – Wet Sow Mold 1 – Start-Up – VDC 1 – Start-up SOP Not Adapted or Not Respected
	1 – Steady State - Wet Equipment 1 – Steady State - Equipment Failure
	2 – Termination – Wet Drain Pan 1 – Termination – Platen Not Stopped

Reduction Plant Main Causes of 66 Incidents – 2020

Transfer Incidents	Reduction Cell
5 - Wet Equipment	2 – Wet Tool / Sampler
3 - Wet Mold Transferring Bath	2 – Wet Anodes 1 – Wet Soda Ash
2 – Wet Sample Mold	1 – Wet Equipment
1 – Bath on Wet Floor	1 – Wet Sampling Tool

FIGURE 37. REDUCTION PLANT INCIDENTS SUMMARY 2020

Reduction Plant Injuries & Incident Causes - 2020

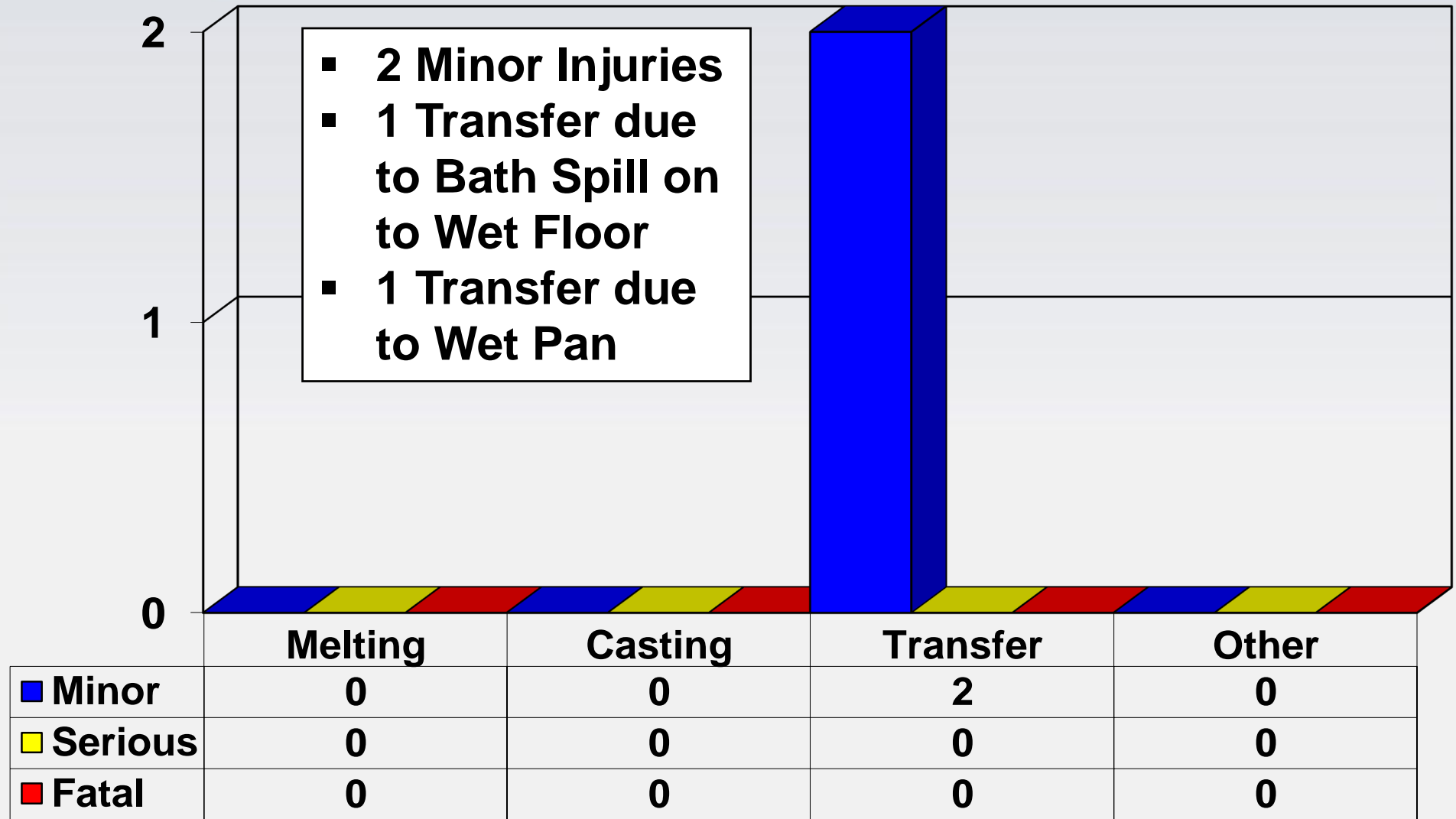


FIGURE 38. REDUCTION PLANT INJURIES BY OPERATION 2020

Oct. 2021

Rolling Plant Injuries - 2020

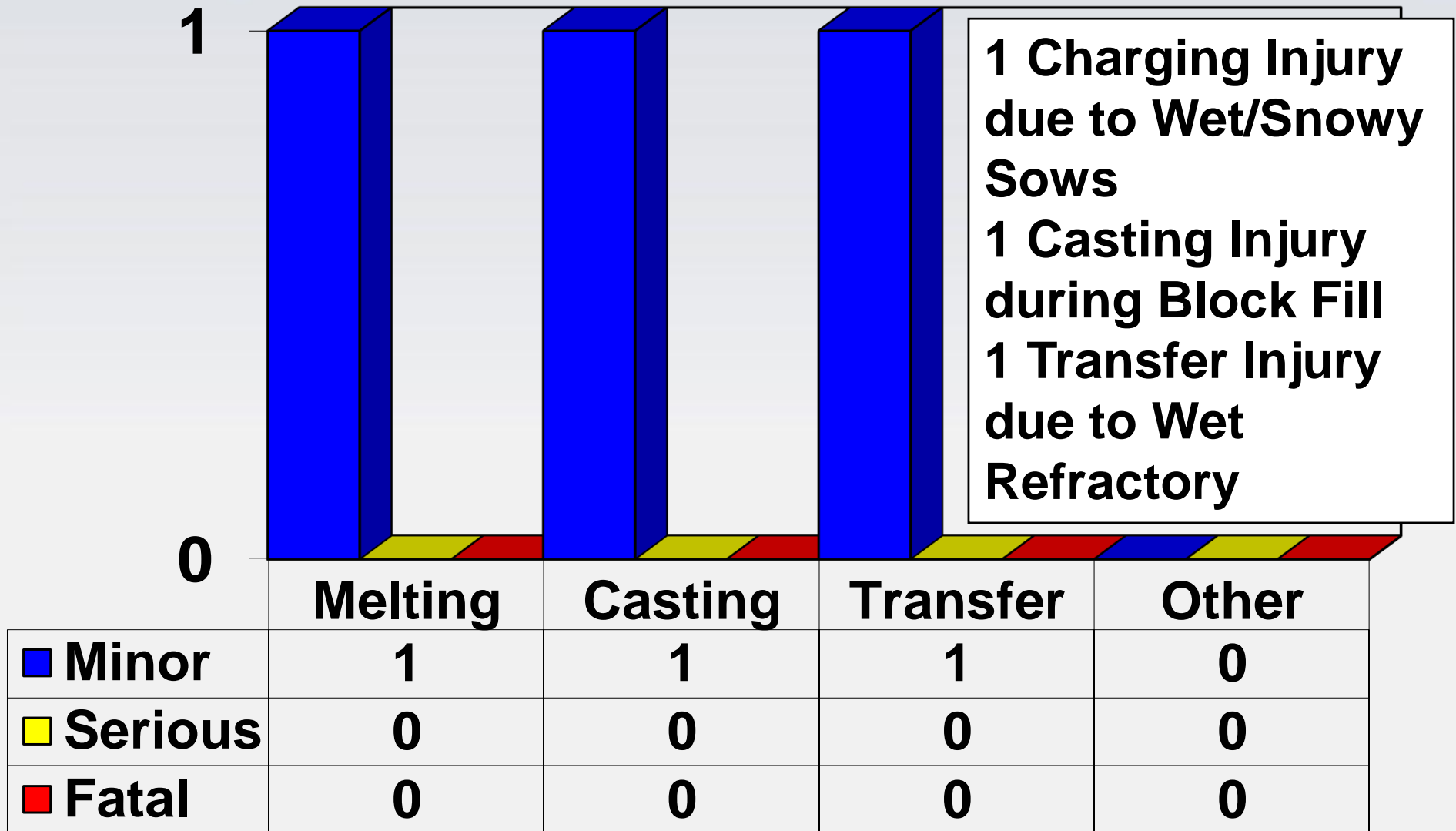


FIGURE 39. ROLLING PLANT INJURIES BY OPERATION 2020

Extrusion Plant Injuries - 2020

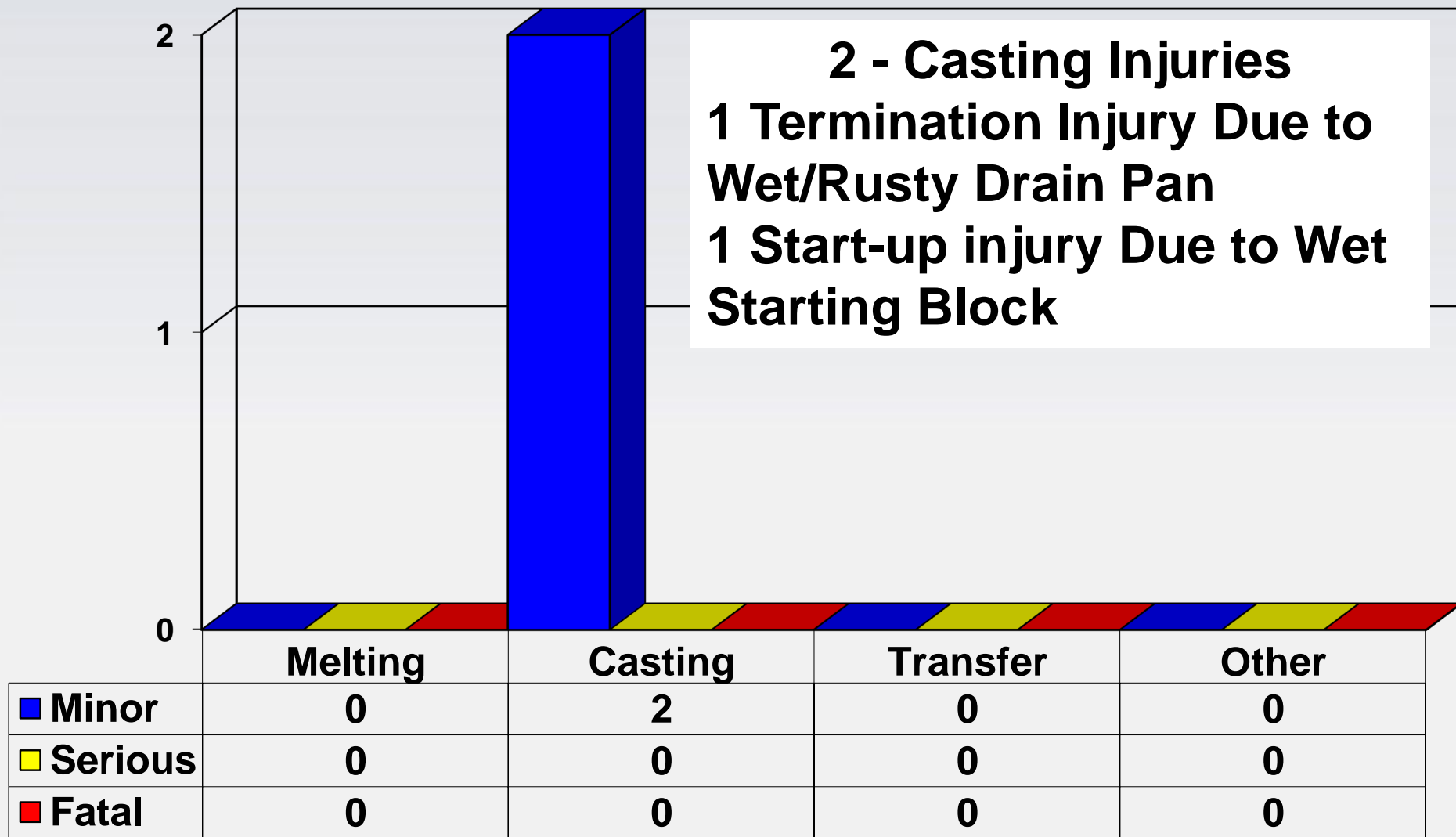


FIGURE 40. EXTRUSION PLANT INJURIES BY OPERATION 2020

Oct. 2021

Recycling Plant Injuries - 2020

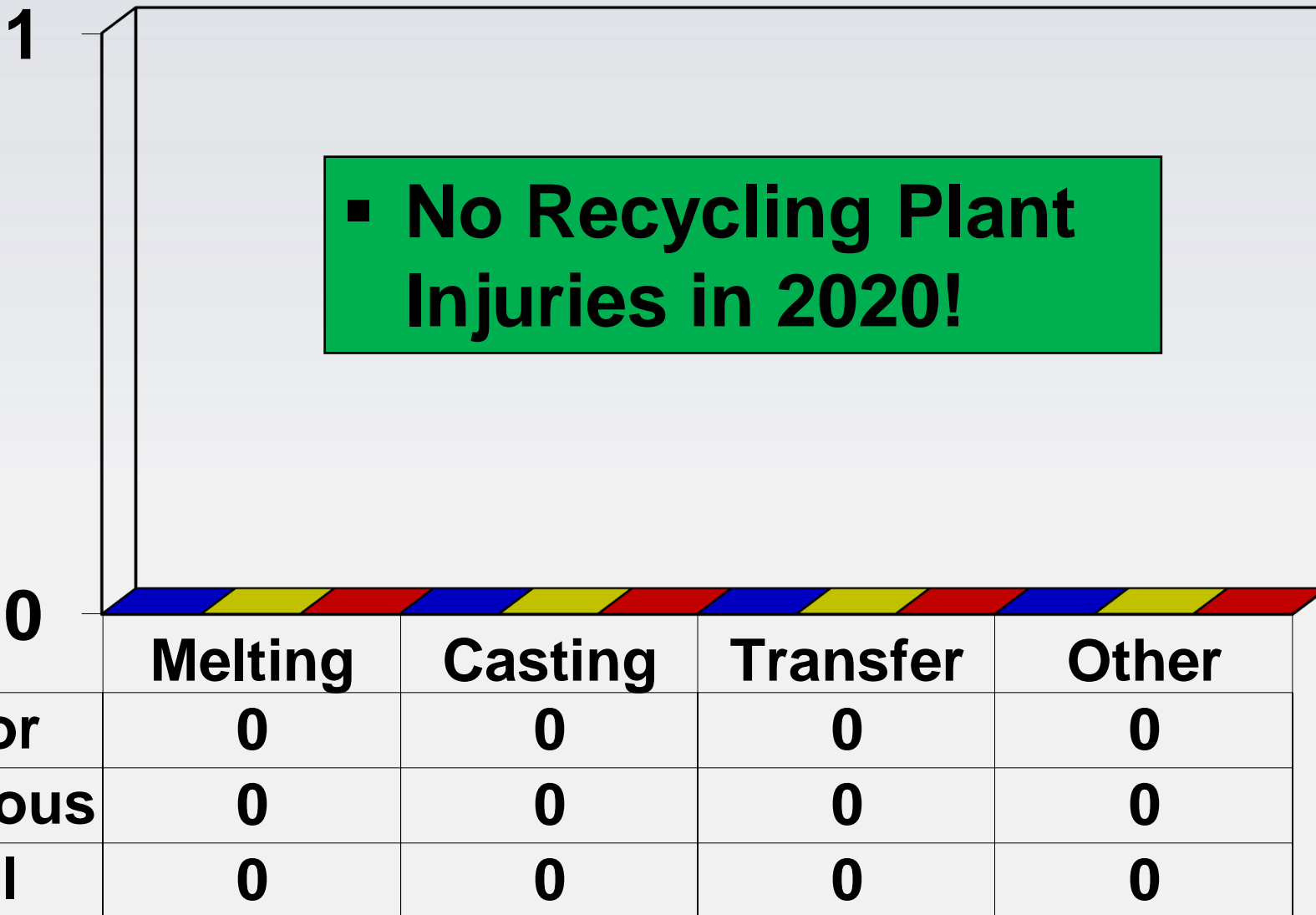
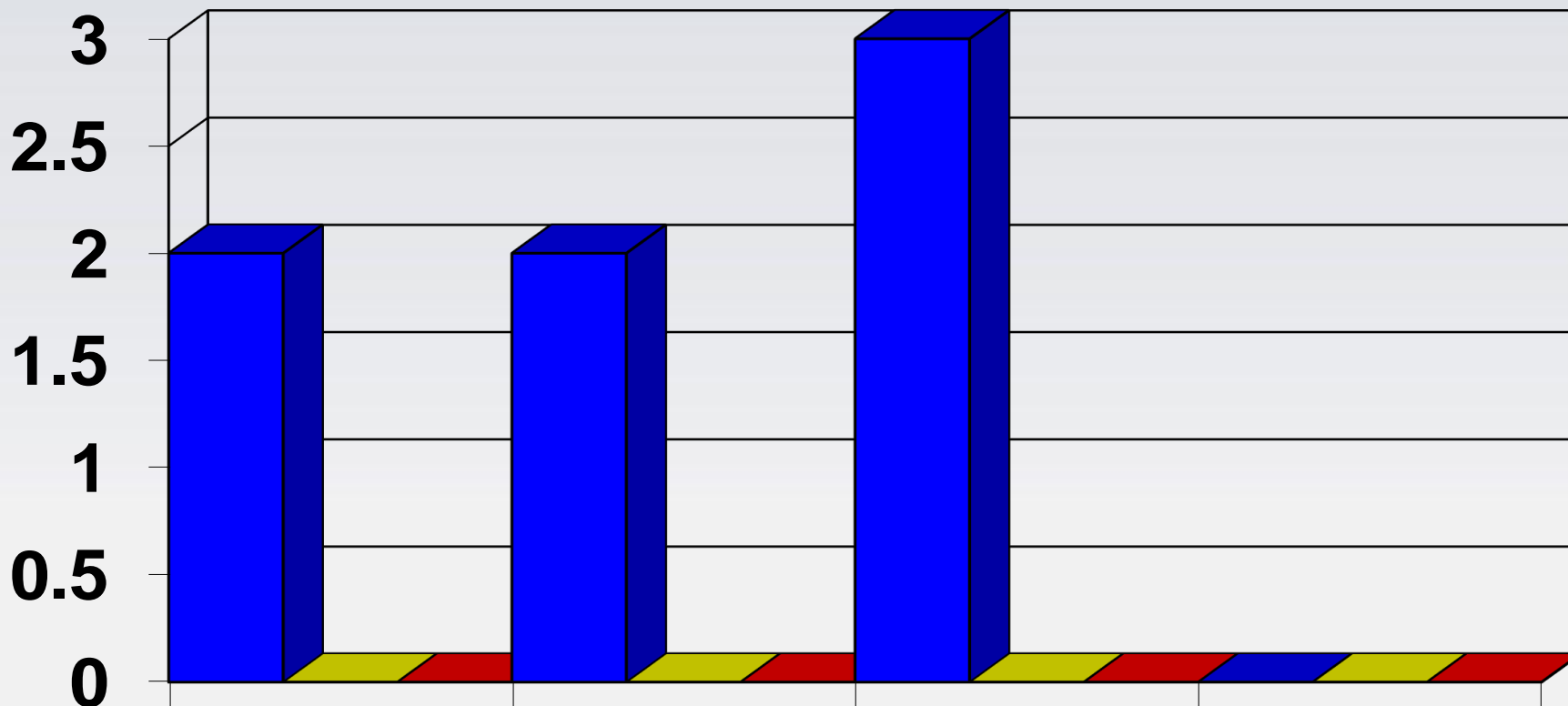


FIGURE 41. RECYCLING PLANT INJURIES BY OPERATION 2020

Injury Severity by Process Plant - 2020



	Reduction	Extrusion	Rolling	Other
 Minor	2	2	3	0
 Serious	0	0	0	0
 Fatals	0	0	0	0

FIGURE 42. INJURY SEVERITY BY PROCESS PLANT - 2020

Oct. 2021

Injury Severity by Process Plant 1980 to 2020

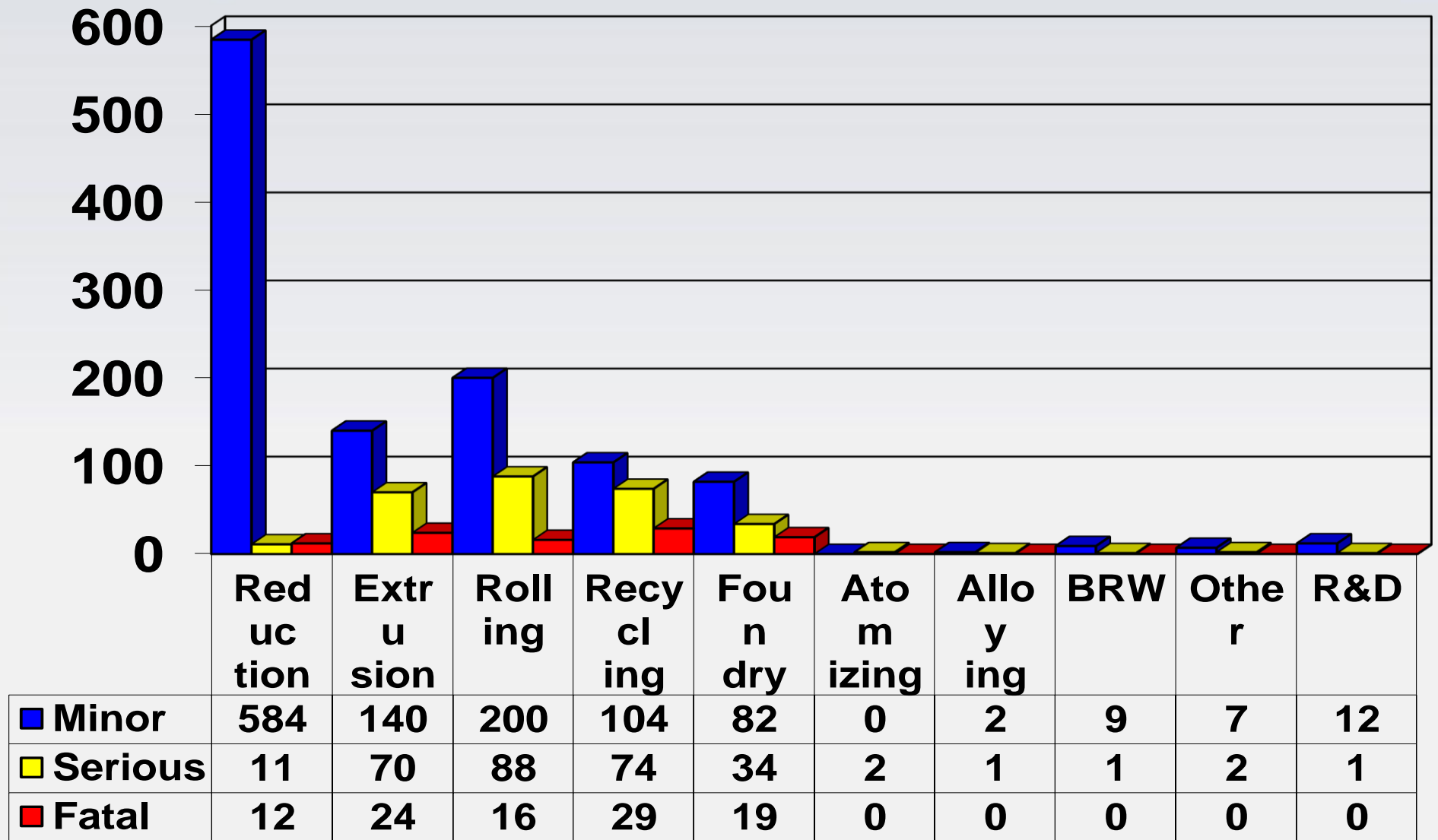


FIGURE 43. INJURIES BY PLANT REPORTED FOR 1980 - 2020

Oct. 2021

ALUMINUM ASSOCIATION MOLTEN METAL INCIDENT REPORT

Date of Incident: _____ Predominant Plant Activity: SELECT ONE:
(month/year)

Explosion Force – Mark One:	Force 1 Characterization: <input type="checkbox"/>	Force 2 Characterization: <input type="checkbox"/>	Force 3 Characterization: <input type="checkbox"/>
For definition of force, click arrow to see a description			
Alloy _____	Metal Temperature <input type="checkbox"/> °F <input type="checkbox"/> °C	Approximate Amount of Metal Involved _____	<input type="checkbox"/> lbs <input type="checkbox"/> kilograms

OPERATION:

Charging / Melting Type of Furnace SELECT ONE:

Furnace Capacity _____ lbs mt % Full _____

Materials Charged _____

Outside Storage? Yes No Preheat? Yes No Preheat Time/Temp: _____ hrs °F °C

Transfer Type SELECT ONE:

Casting Type SELECT ONE: Type of Product being Cast: _____
SELECT ONE:

Stage of Operation: SELECT ONE:

Other Describe _____

Number of Injuries by Type: Minor _____ Severe _____ Fatal _____

Provide a brief description of the incident and its root cause(s): _____

If Charging/Melting Incident, please select appropriate Primary and Secondary cause(s): Other _____ Other _____ If Contaminations (other than moisture) was selected, please specify: SELECT ONE: _____	If Transfer Incident, please select appropriate Primary and Secondary cause(s): PRIMARY CAUSE: _____ SECONDARY CAUSE: _____	If Casting Incident, please select appropriate Primary and Secondary cause(s): PRIMARY CAUSE: _____ SECONDARY CAUSE: _____ If Bleed-out/Bleed-over is selected above, describe reason for Bleed-out or Bleed-Over: _____ If Explosion due to Bleed-out/Bleed-over was selected above, where was the location of Explosions: SELECT ONE: _____ If Metal Level Control Problem was selected above, please specify location of problem: SELECT ONE: _____
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Please return to:

Curt Wells

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