

Ammonium Nitrate – its Behaviour in a Fire, and Recent Changes to the Fire Code

Presentation at the IESSE Conference

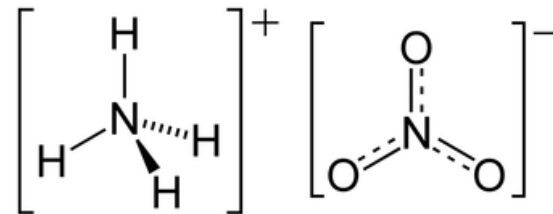
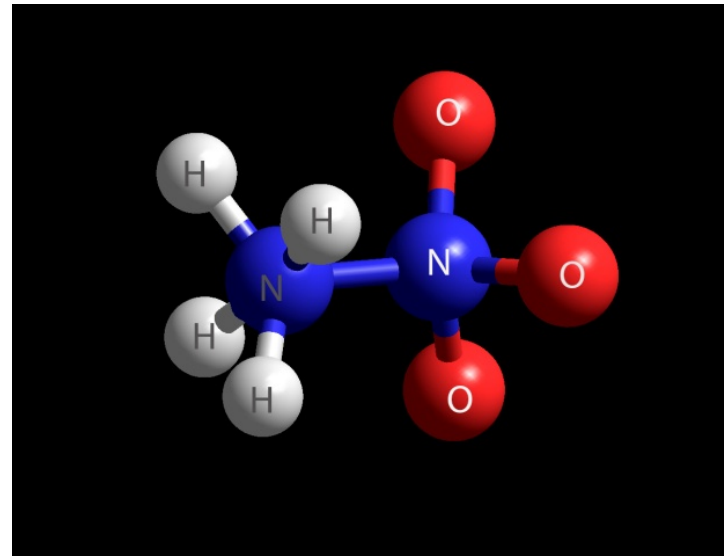
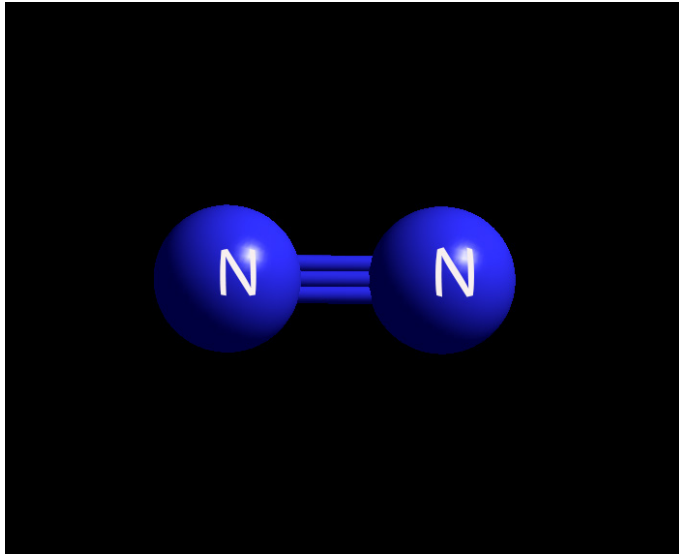
San Diego, CA

August 6 – 9, 2018

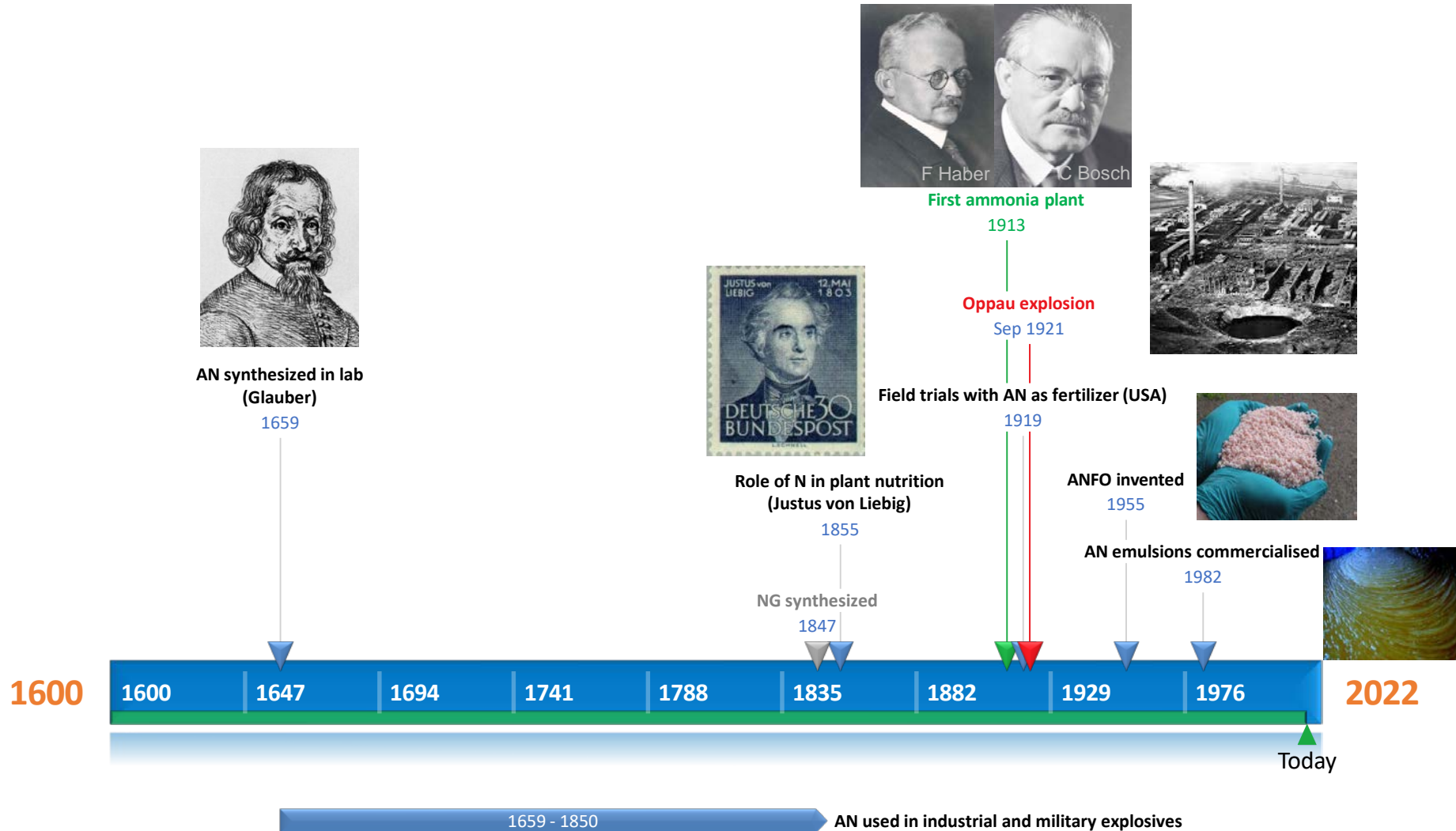
Dr. Noël Hsu

- Ammonium nitrate
 - Manufacture
 - Properties and Reactions
- Explosions involving AN
 - Farmhouse in France
 - West Texas
 - Tianjin
- Government and Industry responded to West Fertilizer explosion

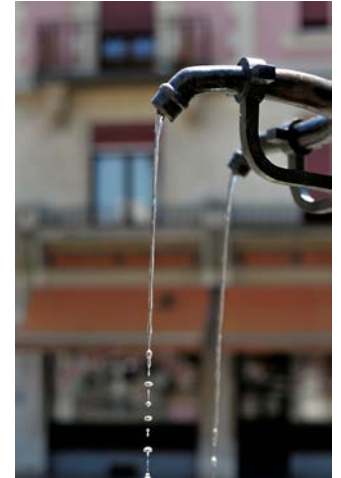
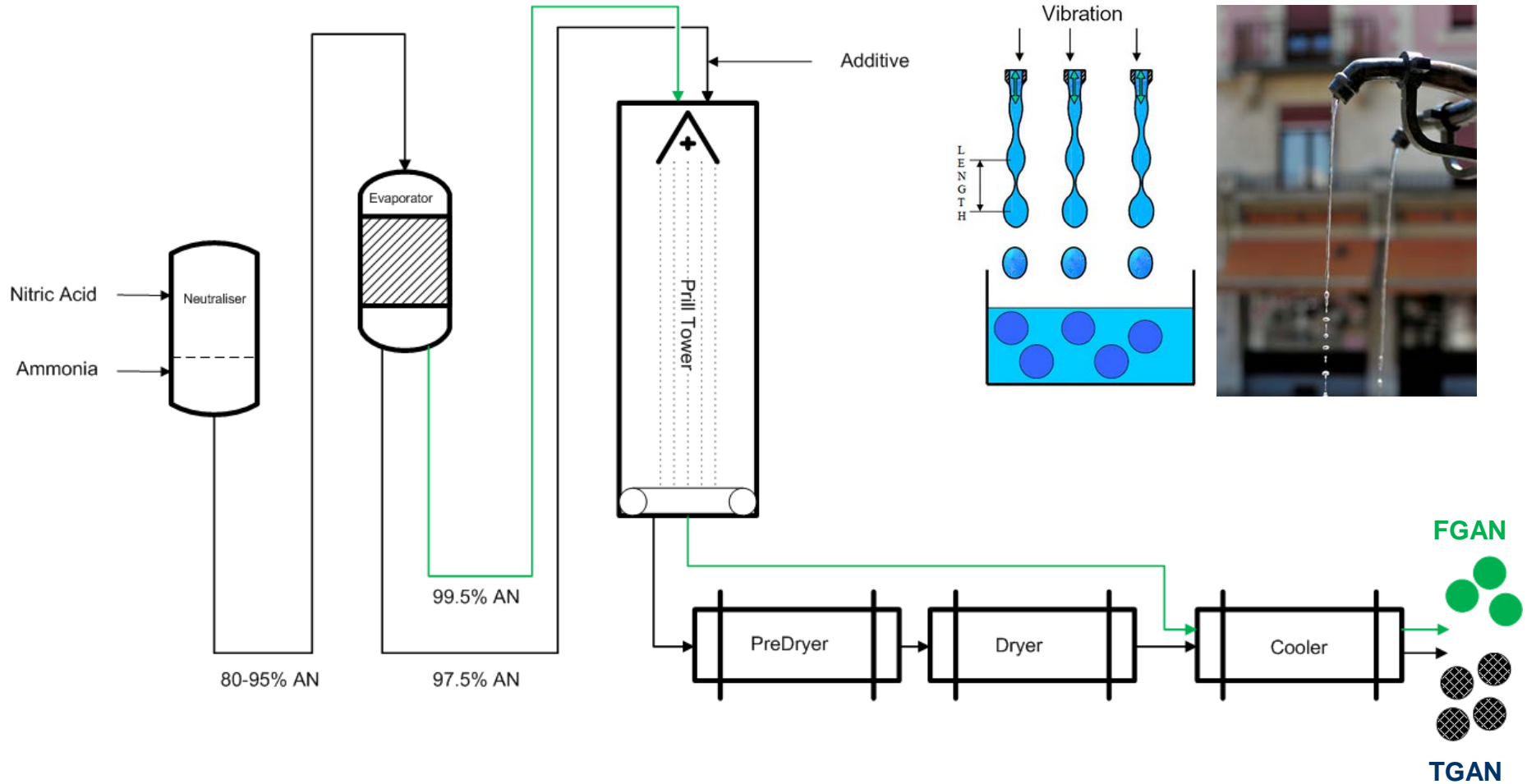
Nitrogen and Ammonium Nitrate



Brief Timeline of Ammonium Nitrate and Related Products



AN Prill Manufacture



2 Main Physical Forms of AN



FGAN

TGAN

Decomposition Reactions of AN¹



| | | |
|----|--|-------------------------------|
| 1. | $\text{NH}_4\text{NO}_3 \rightleftharpoons \text{NH}_3 + \text{HNO}_3$ | $\Delta H +44.6$ (kcal/mol) |
| 2. | $\text{NH}_4\text{NO}_3 \rightarrow \text{N}_2\text{O} + 2\text{H}_2\text{O}$ | $\Delta H -8.8$ |
| 3. | $2\text{NH}_4\text{NO}_3 \rightarrow 2\text{N}_2 + \text{O}_2 + 4\text{H}_2\text{O}$ | $\Delta H -28.2$ |
| 4. | $2\text{NH}_4\text{NO}_3 \rightarrow \text{N}_2 + 2\text{NO} + 4\text{H}_2\text{O}$ | $\Delta H -6.6$ |
| 5. | $3\text{NH}_4\text{NO}_3 \rightarrow 2\text{N}_2 + \text{N}_2\text{O}_3 + 6\text{H}_2\text{O}$ | $\Delta H (- 20.8$ from data) |
| 6. | $4\text{NH}_4\text{NO}_3 \rightarrow 3\text{N}_2 + 2\text{NO}_2 + 8\text{H}_2\text{O}$ | $\Delta H -22.2$ |
| 7. | $5\text{NH}_4\text{NO}_3 \rightarrow 4\text{N}_2 + 2\text{HNO}_3 + 9\text{H}_2\text{O}$ | $\Delta H -29.4$ |

- Reaction 2 prevalent up to about 250°C
- Reactions 3 to 6 mainly occur above 300°C and are usually associated with explosive and detonative behaviour
- Reaction 7 was found to occur in presence of spongy Pt and g. HNO₃

Texas Fire Marshall Report



Fires in West and Bryan, Texas



Call made to 911



Flames observed



Firefighter arrives on scene



Engine 1 asked Engine 2 to hookup to hydrant



West



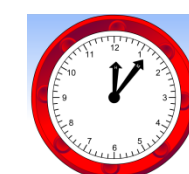
Call made to 911



Firefighter arrives on scene



Bryan Fire Dept on scene



½ mile evacuation ordered

Bryan



As the building became more involved the roof collapsed and an explosion occurred.

Fire in Farmhouse in Saint Romain-en-Jarez³



Fire broke out inside barn

October 2, 2003



Fire fighters notified



Fire fighters arrived on scene and began battling violent blaze

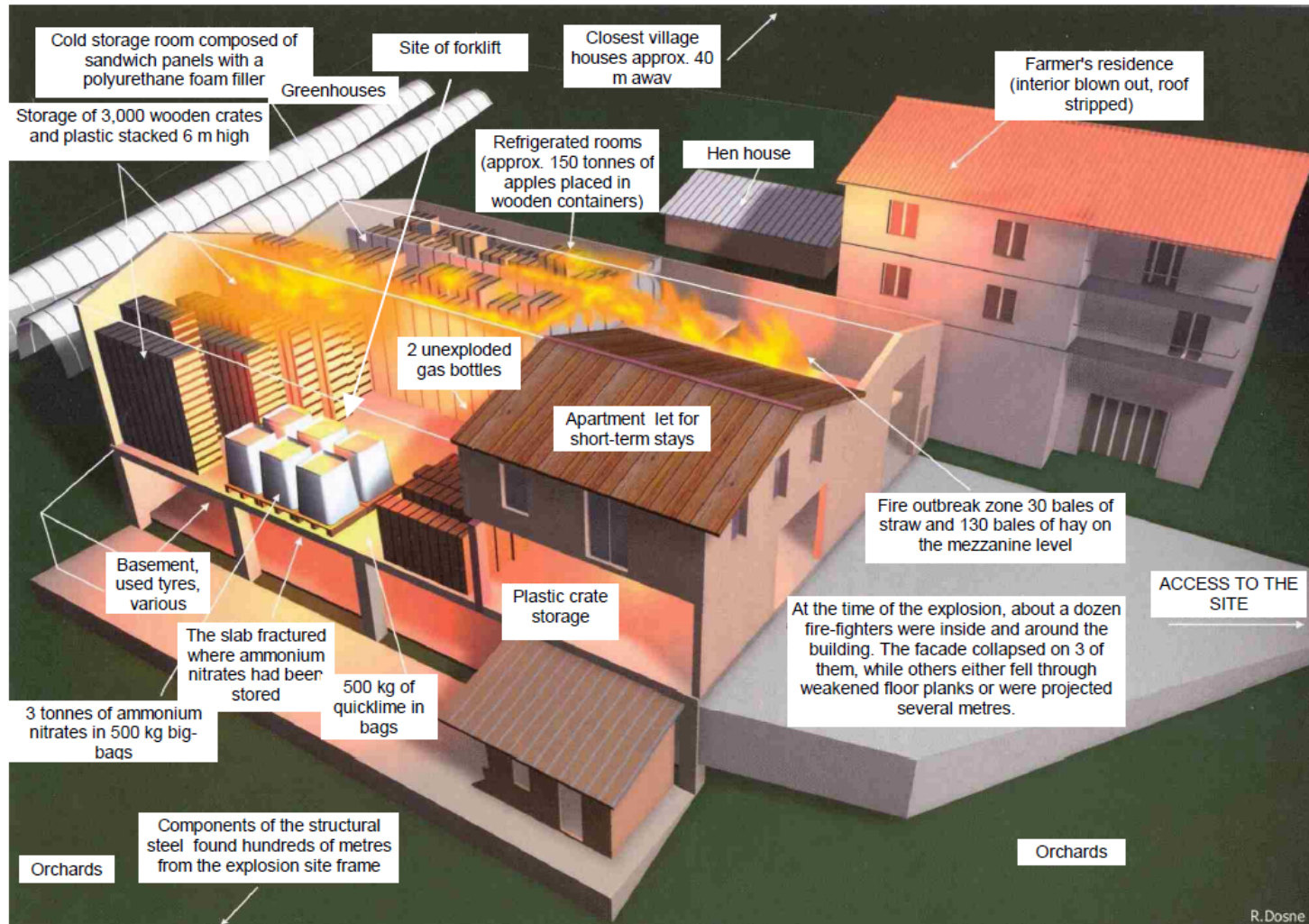


Captain called for 'water supply backup'



Large portion of barn roof already collapsed.
Hissing sound heard followed by powerful explosion

Fire in Farmhouse in Saint Romain-en-Jarez



Explosion of ammonium nitrate solution inside the barn (drawing by René Dosne, "Face au Risque", issue 399, January 2004)



- **Steel structure with concrete block filling**



- **18 Firefighters injured**
- **3 Gendarme, slightly hurt**
- **5 bystanders, slight injuries**

Tianjin Port



August 12, 2015



Explosion ~40 minutes after first fire reports

- use of combustible materials of construction,
- no sprinkler requirement
- no zoning requirement



EO 13650
Aug 2013

- Review chemical hazards
- Determine if RMP and PSM Std should be expanded

Senate Testimony
Jun 2013

OSHA RFI
Dec 2013

2013 | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | 2013

Apr 2013
West Texas Explosion

Jul 2013
IME Guidelines



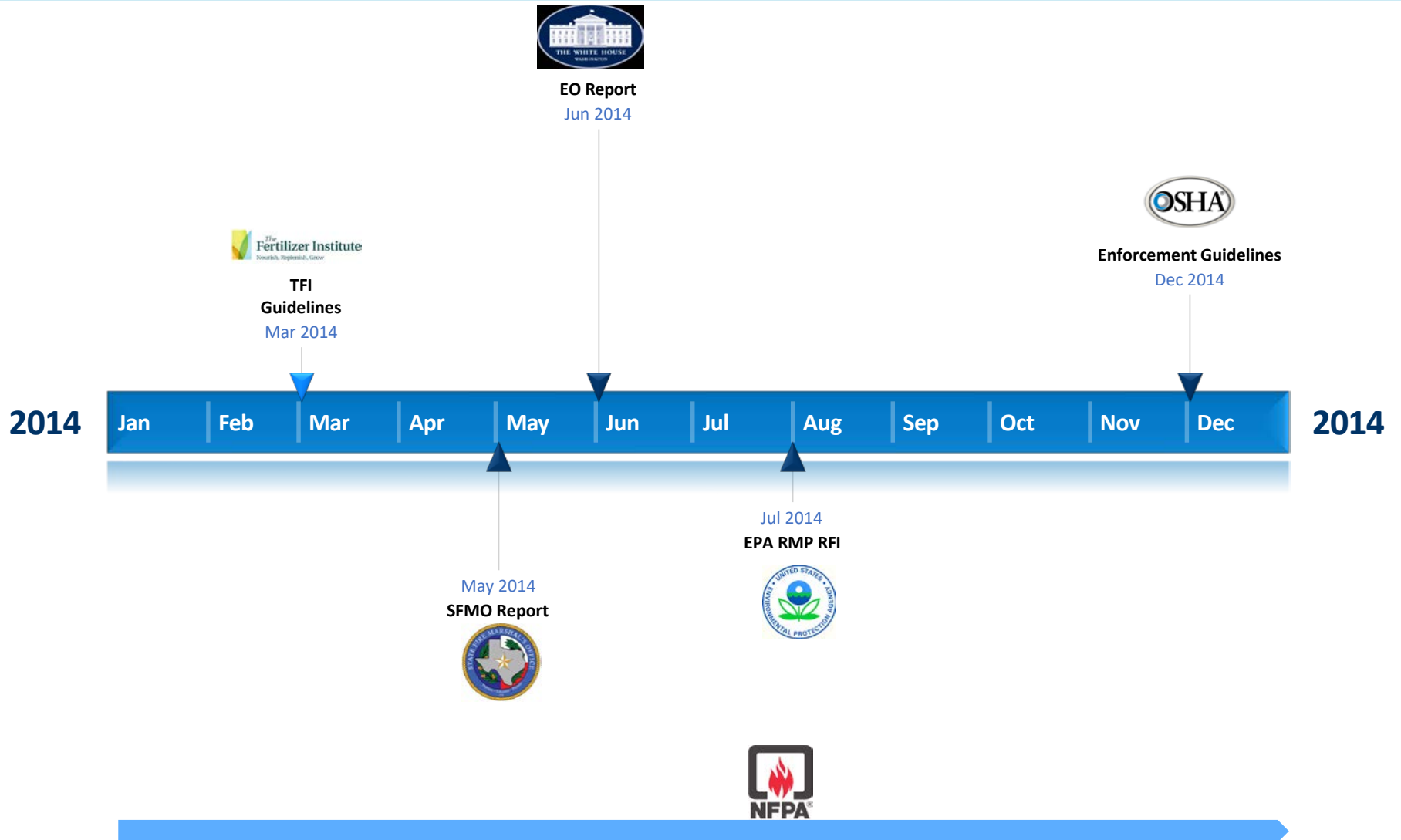
- Use of non- combustible materials of construction;
- Do not fight fires;
- Written emergency plan

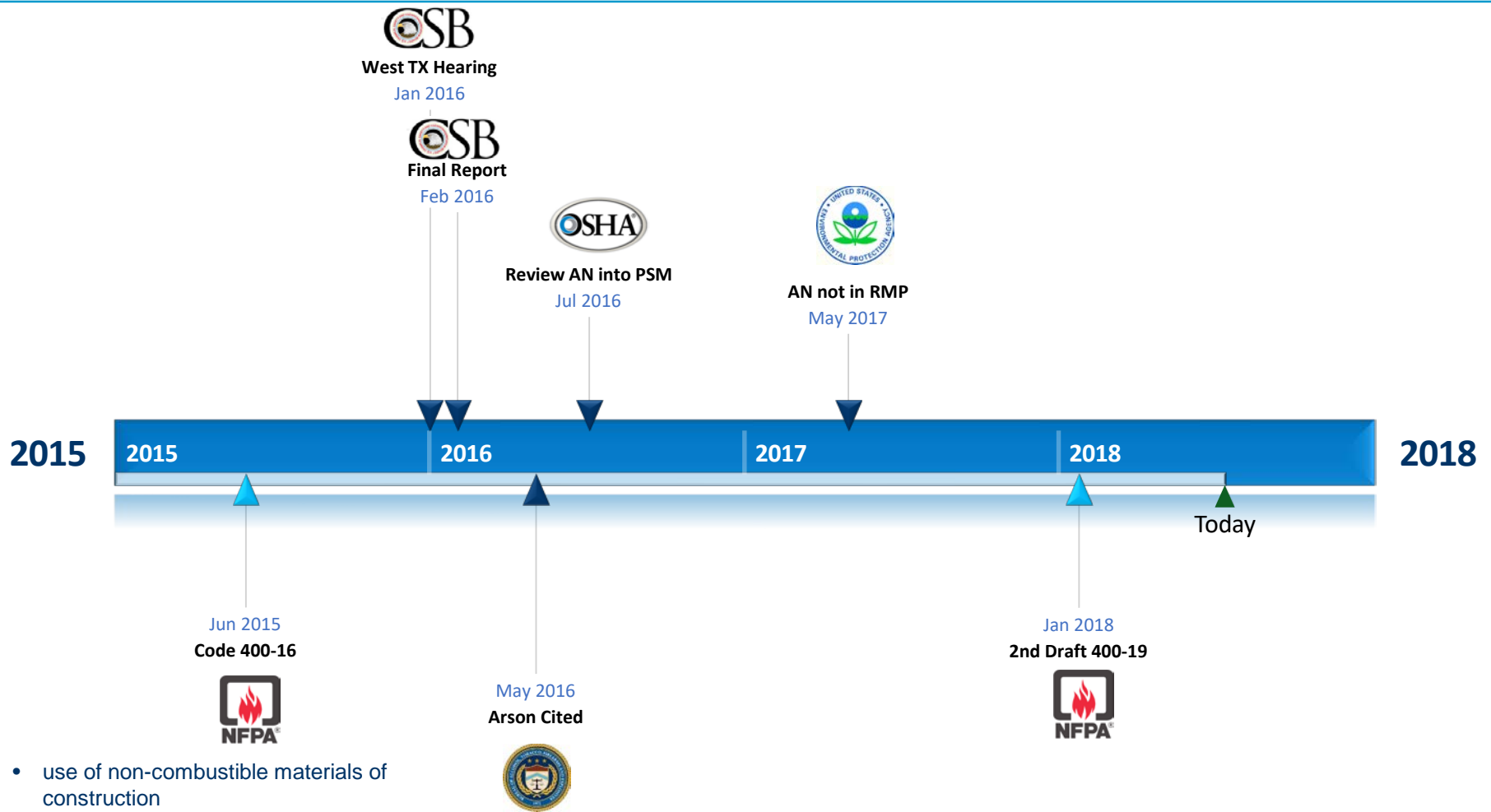
Aug 2013
Advisory Issued



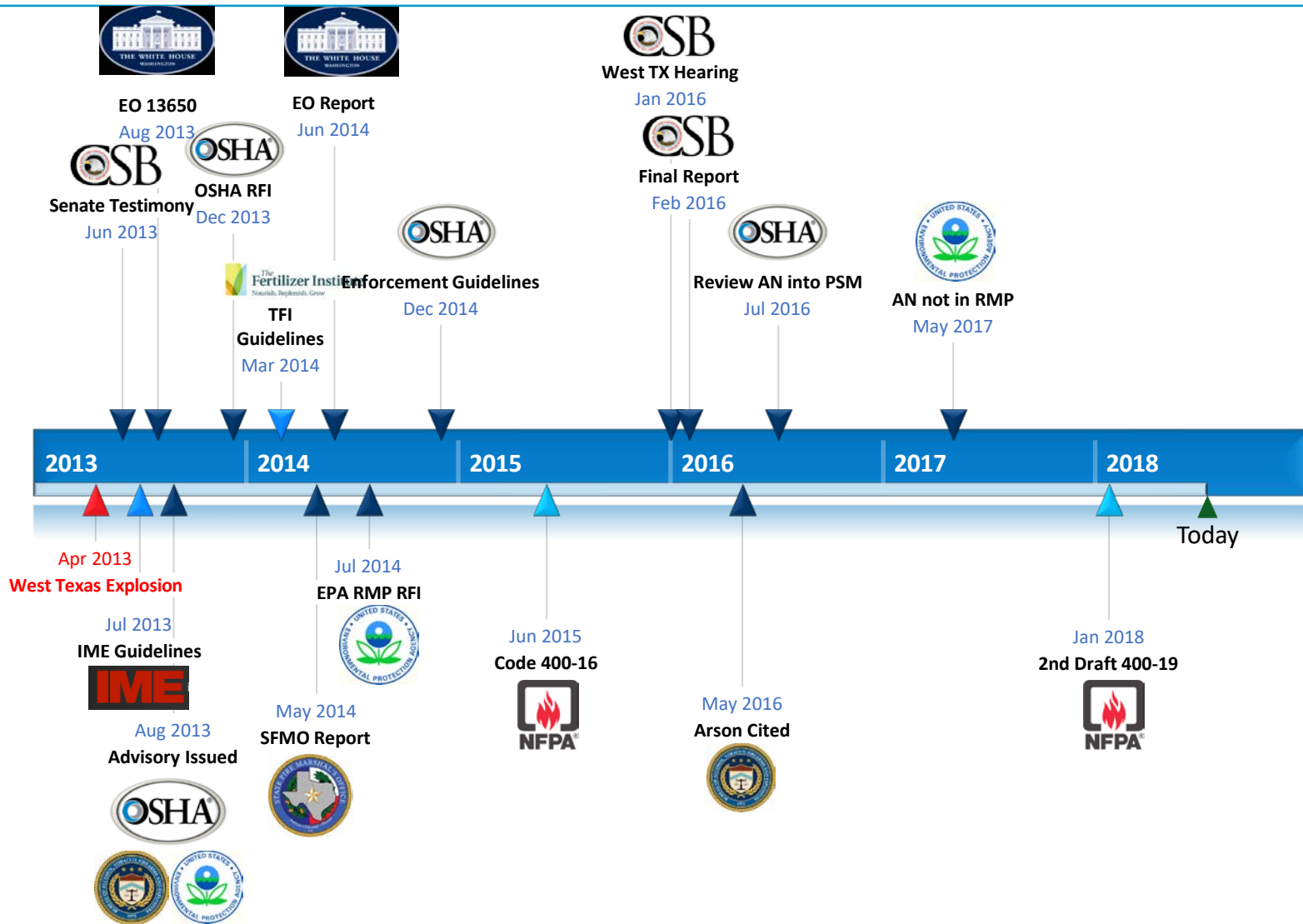
- Guidance on storage of AN
- Refers to NFPA Code 400, and IME Guidelines, among others







- use of non-combustible materials of construction
- automatic sprinklers, retroactive
- Emergency action plan – evacuation distance 1 mile
- Comprehensive list of incompatible materials



Overview of Fire Code Controls

