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FROM THE DESK OF THE SECRETARY GENERAL

The year is rushing past and we are on the downhill side of 2017. Although the business environment has eased somewhat the industry is still taking strain in some areas.

A big concern is the loss of expertise in the industry through retirement and restructuring. SAFEX International realized this about 8 years ago and started the eLearning Portal Workgroups and training sessions at Congresses to assist with increasing the level of expertise in the industry. The portal was started with the Basis of Safety Module in English -this has since been translated into Spanish and French .A Russian version will also be available soon . Other modules have been added, Management of Change and Incident Investigation. Modules on Pyrotechnics, Secondary Explosives, Primaries and Explosives Classification are to be added by year end .**Please use these modules in your company to raise the barrier to any incident potentially occurring** .The article "Sharpening the Saw" deals with training and opportunities at Cranfield University .Cranfield is also the host of the SAFEX eLearning Portal and assists the SAFEX Community very capably.

During the last three months SAFEX only had three incidents reported:

IN17-09 Delay Powder Initiation

IN17-10 HMX Incident

IN17-11 Smokeless Powder Incident

I urge you again please report – any incident or potentially critical occurrence is a point of learning for whole the industry.

In this Newsletter we continue with the "Did you know that.."series and also start a new feature in which readers supply photos of good and bad practices to ensure the lessons learn 't are shared in the industry.

Watch this space for news about the next Congress in 2020.

SAFEX International would also like to take this opportunity to congratulate our Chairman, John Rathbun , with his resent appointment as President of the Austin Powder Holding Company .We wish John all the best for a very successful future and look forward to his continued dedication to safety and SAFEX.

Sharpening the Saw

by

Jackson Shaver

Like many households, my teen and college-age children are thrilled with the end of the school year and basking in what they perceive as freedom. My wife sees it otherwise and they are now engaged in alternative academic pursuits. The attitude that when school is over, learning stops, is probably not isolated to youth as some professionals cringe when professional development or mandatory training is required to maintain certification or sustain professional skills. For peers in business, medical sciences, social sciences, information technology and other occupations, educational and academic opportunities seem boundless. For those who manufacture Explosive Substances and Articles(ESA), opportunities for professional development may not be readily available or may be perceived as too costly for frequent participation. So, how can we, as Steven Covey would say “sharpen our saw” as ESA professionals and where do opportunities exist?

Fortunately, SAFEX and others present opportunities for ESA professionals to participate in coursework on-line or attend on-site when possible. Recently, I had the opportunity to visit Cranfield University and discuss academic and professional development coursework with Dr. Jackie Akhavan and Dr. Ranko Vercelj. I was introduced to the Cranfield University on-line training courses a few years ago by a colleague at SAFEX and looked forward to visiting the campus when the opportunity was presented. The SDI/Daicel library has a text written by Dr. Akhavan, The Chemistry of Explosives. I have referred several engineers to this text as an excellent guide to understand energetic material chemistry and the examination of energetic material categories and behaviors.

Cranfield University offers many different opportunities for ESA professionals to develop and gain knowledge that will enhance professional skills. Opportunities for professional development on-line and on-campus are available. It would be well to examine the short course listing, on-line listings and schedules for examination at www.cranfield.ac.uk. To date, I am not familiar with any university that can provide comparable, comprehensive opportunities for ESA professionals. Coursework related to Explosive Fundamentals and Explosives and the Environment quickly drew my interest. Further, there is opportunity for customized coursework that may be of interest to many ESA manufacturing companies. I sincerely appreciated the opportunity to examine the Cranfield University campus facilities and capability first hand.

While discussing a complex manufacturing engineering challenge with our team last week, we debated a number of solutions and analytical tools that could be applied to the problem. During the conversation I shot down a recommended solution by a new engineer. Well the discussion bothered me enough to examine it after the meeting. In truth, 1) he was right; 2) I delivered an apology; and, 3) I have the opportunity to “sharpen the saw” regarding electrical analytical instrument capability. Fortunately, my children will be sitting at the kitchen table to encourage my progress with electrical analytical instruments and explosives and the environment.

http://www.machinedesign.com/learning-resources/value-continuing-engineering-education
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Thermal Explosion, Deflagration, and Detonation Hazards of Ammonium Nitrate and Water-Based Emulsions

by

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1. Introduction

Soon after the slurry explosive became popular in blasting applications, another water-based ammonium nitrate (AN) system was invented: the emulsion explosive (1961). It consisted of microscopic droplets of a liquid oxidizer solution surrounded by a continuous oil phase. The first stable and practically useful emulsion blasting explosive was developed by H. F. Bluhm in the USA (1969) [1]. However, the successful commercialization of this type of explosive did not really happen before the beginning of the 1980s. In these emulsions, the liquid oxidizer phase usually consists mostly of AN with various other oxidizing salts such as sodium nitrate (SN), calcium nitrate (CN) and sodium perchlorate (SP). In this manuscript, we will refer to these products as ammonium nitrate and water-base emulsions (ANWEs).

From a safety point of view, the obvious advantage of ANWEs was their apparent insensitivity to common physical stimuli such as impact, friction, and electrostatic discharges. From a processing point of view, they also offer desirable flow properties at typical operating temperatures so that very large quantities can be handled by mechanical means (pumps and augers). This gave rise to large-scale bulk emulsion technology, which allowed several tons of ANWEs to be transported from a local satellite plant to a mine site and loaded directly into boreholes using such mechanical systems.

While these newer explosive products proved beneficial for both the manufacturers and the users, the apparent insensitivity of ANWEs led to the false belief that the level of hazard was inherently low [2]. However, it soon became obvious that such high-volume/elevated-temperature and pressure processes were more hazardous than initially thought as many accidents, some leading to fatalities, were reported in the following decades [3-5].

When a relatively large mass of ANWE is heated to temperatures above approximately 200°C, it will start reacting exothermically and this will lead to self-heating. Whenever this self-heating is not counter-acted by means of sufficient cooling, it will lead to higher temperatures, which will enable a faster reaction rate and, therefore, to a faster self-heating rate. It is expected that this may escalate and lead to an uncontrolled thermal explosion (or cook-off event) in which the complete mass of ANWE will react violently and very rapidly. Scenarios of this kind may occur for instance when a sizable mass of ANWE is exposed to a fire – same applies to a small mass under confinement or if a pump is allowed to run dry or is deadheaded on a blockage. In this latter case, if the pump is not stopped, mechanical energy delivered by the pump motor continues to be converted into heat that will increase the temperature of the product possibly up to the onset temperature of the product [6]. A similar scenario can also result from prolonged contact of the ANWE with an incompatible chemical. AN is known to be incompatible with many other chemicals [7]. In particular, sodium nitrite, which is used as the basic ingredient for chemical gassing of ANWEs, has been demonstrated to be incompatible with AN [8] under uncontrolled addition or gross contamination and was proposed as a root cause for some incidents degenerating into explosions [5].

If a sufficiently large quantity of thermal energy is deposited locally into the ANWE, ignition may occur and may evolve into a deflagration (subsonic self-sustained combustion reaction). This may happen, for example, in the case of a compression/ignition event originating from the compression of an air void imbedded in a pumping system [9]. Another plausible scenario in which thermal energy is deposited may be the development of a localized high temperature frictional hot-spot following the ingress of metallic foreign objects in pumping/mixing systems. .In both cases, specific conditions related to intrinsic ANWE properties are required for the ignition to take place and to propagate to a full deflagration. If these conditions are met and the ANWE is contained in pumping and mixing vessels, the deflagration will accelerate as the burning rate increases with pressure up to a point where the vessel can explode if its pressure resistance is exceeded. The most severe hazardous event that can result from local thermal ignition of ANWEs would be a DDT (deflagration-to-detonation transition) for which the above well confined deflagration is allowed to build-up to a supersonic detonation.

Another type of hazardous scenario that may lead to a detonation is if hot ANWEs are exposed to high-velocity projectiles produced by a nearby explosion in process equipment. In this case, if the projectiles are sufficiently energetic, shock initiation of a detonation into the ANWE may be achieved.Many intrinsic properties of ANWEs, such as formulation, thermal conductivity, and viscosity have significant influence on the hazards they may represent. At the Canadian Explosives Research Laboratory, many ANWEs have been studied in the last two decades in order to find out more about these properties. All the known hazards from ANWEs are thermal in origin even if they result from pressure related mechanisms. As discussed above, the induced reaction scheme leading to a hazardous scenario depends on how the thermal energy is applied to the system.

In this paper, some techniques to experimentally measure hazardous properties of ANWEs will be reviewed. The results from these measurements will be discussed in the context of the three most likely hazardous scenarios discussed above.

2. Thermal Explosion of ANWE

2.1. Small-scale thermal analysis

The thermal stability of an ANWE formulation lies in its ability to resist undergoing a thermal explosion when exposed to heat. The formulation of the specific ANWE plays a major role in determining the temperature at which it will start self-heating (the so-called onset temperature “T_o” for thermal runaway). Earlier reported studies to characterise the thermal stability of ANWEs were typically performed using small-scale thermal analysis techniques such as Differential Scanning Calorimetry (DSC). Since these tests are normally performed using very small samples (typically 0.5 to 3 mg) and relatively fast heating rates, the measured onset temperature for exothermic decomposition may be substantially higher than that applicable to industrial quantities. Therefore, while the measured “DSC onset temperature” is of limited value for thermal hazard quantification, the technique can be very useful as a screening tool to reveal instabilities possibly induced by various admixtures of incompatible chemicals [10]. Due to the small scale of the DSC samples, mixtures with various proportions of specific chemicals are difficult to reproduce and, therefore, these types of results should be regarded as qualitative indicators.

In programmed “closed” DSC experiments on ANWEs, two exotherms were evidenced above 200°C while only one was present for neat AN [11]. This was thought to be due to reaction of nitric acid with the hydrocarbons of the oil phase. It was also observed that the extent of the early decomposition (i.e. first exotherm) depended on the oil content of the ANWE [11].

The DSC technique also allows one to measure the Arrhenius kinetic parameters for the exothermic decomposition of ANWE and various ASTM standards can be used for this purpose [12]. Often, such kinetic parameters determined from small-scale methods have been used in conjunction with the Frank-Kamenetskii model [13] to predict the behaviour of large-scale systems. It should be mentioned that this should be done with caution, as the parameters determined in one temperature domain by DSC may not be applicable to larger systems in a temperature domain appreciably lower than that covered by the measurements. Larger-scale cook-off experiments should be performed to test these predictions beforehand [10, 11].

Another small-scale technique has also been used at the Canadian Explosives Research Laboratory to characterize the thermal decomposition of ANWEs [14]. It uses a combination of a simultaneous DSC-TGA apparatus (TA – Q600 SDT) interfaced with a FTIR (Nicolet 6700) and a mass spectrometer (Balzers Thermostar GS300). A schematic diagram of this combination is shown in Figure 1.

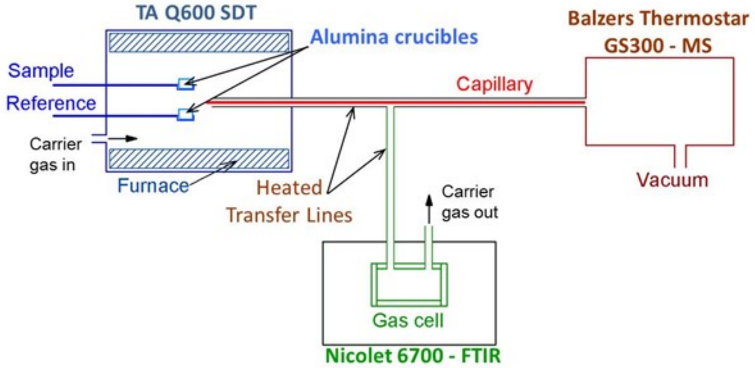

Figure 1 .Schematic diagram of the simultaneous DSC-TGA-FTIR-MS technique used at the Canadian Explosives Research Laboratory

Typical results from an experiment on an ANWE sample are shown in Figure 2. The DSC and TGA data are displayed in the top graph. It can be observed that, contrary to the earlier “closed” DSC results [11] the decomposition in “open” alumina crucibles produces only endothermic activity. This illustrates well that small-scale experiments, especially in “open” configuration, may strongly underestimate the thermal hazards evaluation of a particular sample. The observed heat flow curve corresponds well with the measured mass loss behaviour. The latter starts close to room temperature with mostly water evaporation and NO_2 evolution being observed. Soon after the AN melting endotherm (170°C), the mass loss accelerates as more AN dissociation products are observed (see FTIR data in centre graph). Some CO_2 is also generated due to reaction of these products with the hydrocarbons of the oil phase, as discussed in [11]. The MS data (lower graph) correlates relatively well with the FTIR data.

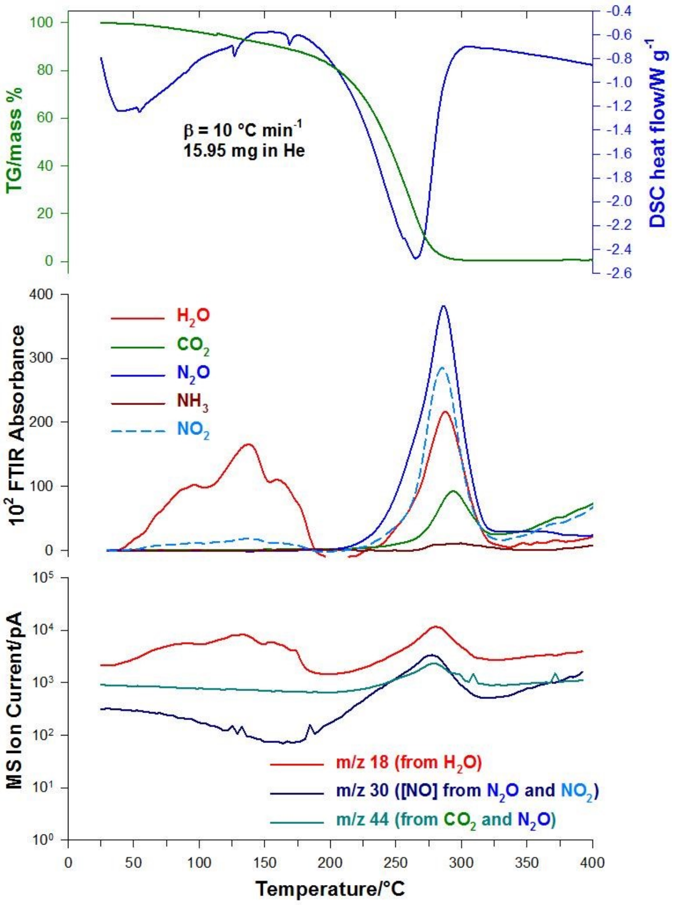

Figure 2 .Simultaneous DSC-TGA-FTIR-MS data for a typical sample of ANWE

2.2. Larger-scale thermal experiments

Other larger-scale thermal experiments such as Accelerating Rate Calorimetry (ARC) [15] and Adiabatic Dewar Calorimetry (ADC) [16] have also been used to characterise the thermal explosion hazards of ANWE [17, 18, 19].

In the “closed” ARC experiments [18] using 1 to 3 g of sample material, two separate exotherms were also evidenced as shown in Figure 3. In order to avoid explosions in the calorimeter, these experiments were both terminated when the self-heating rate reached 1 °C min^{-1} and, therefore, the second exotherm is not completely observed. In this case, it was also observed that the extent and onset temperature of the first exotherm depended on the nature and abundance of the oil phase. In Figure 3, the oil phase of the packaged product was very different from that of the bulk product (proprietary formulation). It is seen that for the packaged product, self-heating could be detected at temperatures as low as 150°C. It was also verified that, if this sample was kept isothermally at 150°C, the system was pushed to runaway only about 1 hour after reaching this temperature [18]. In both cases, experiments on the oil phase alone did not produce low temperature exotherms. Therefore, here again it is concluded that this first exotherm is likely due to the reaction of some AN dissociation products with hydrocarbons from the oil phase.

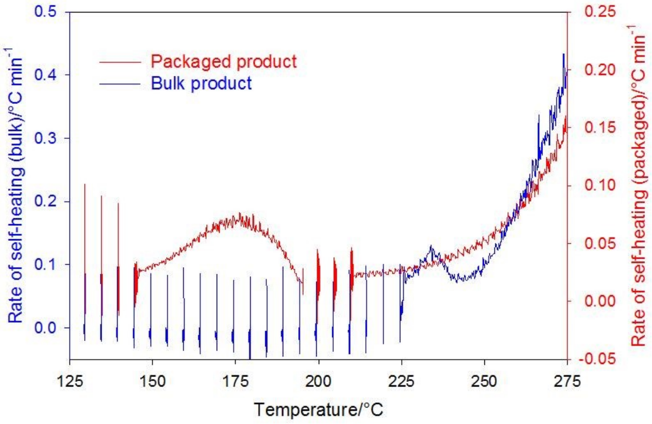

Figure 3 Typical ARC results for a packaged (red) and a bulk (blue) emulsion formulations

For the ADC experiments, typically 100 g samples were used in a 1-L insulated Dewar flask that could be operated in both “open” and “closed” configuration [18]. A schematic of this experimental arrangement is shown in Figure 4. Quasi-adiabatic conditions were obtained by very slow oven heating (2 °C h^{-1}) through the walls of the Dewar flask.

For AN-based systems with no oil phase, it was found that the ADC onset temperature is 10 to 20°C lower than the corresponding ARC onset. In this case, it was also found that when the data are extrapolated taking the thermal inertia into account, the extrapolated onset temperature for both the ARC and ADC data sets are within 10°C of each other for an uninsulated 20 m^3 storage vessel. Clearly, this does not hold for ANWE systems since, as shown in Figure 3, the oil phase can contribute to a first exotherm at somewhat lower temperature. This was clearly observed in Dewar experiments on unsensitised bulk emulsions for which onset temperatures for this first exotherm were found to be as much as 40°C lower than the corresponding ARC onset [18]. In at least one case, the runaway was too rapid for the experimental procedure. The sample was completely consumed, with measured temperatures as high as 600°C. However, damage to the

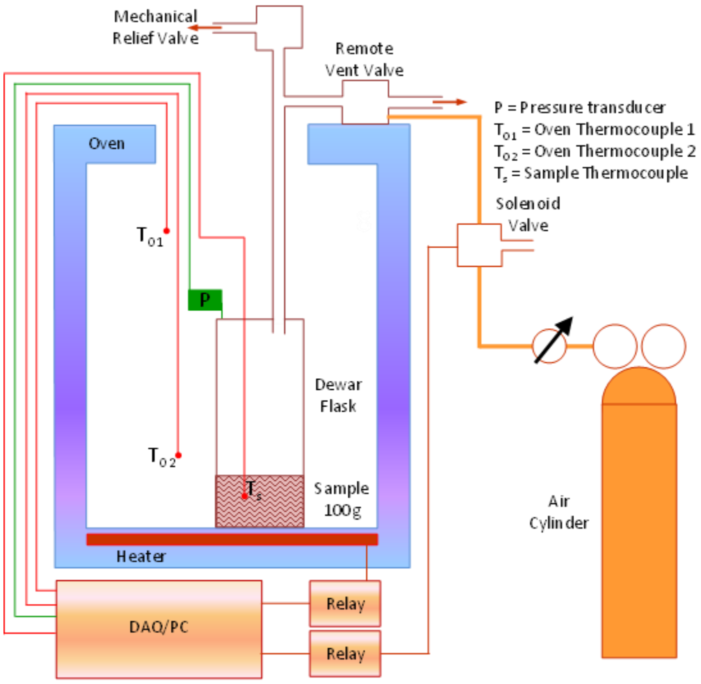

Figure 4 Schematic of the Dewar Apparatus built at the Canadian Explosives Research Laboratory

experimental facility was quite limited (Figure 5). The results of similar Dewar tests have been employed in conjunction with the Frank-Kamenetskii model to predict the heat production during the transport of emulsions at elevated temperature in up to 25000-L tankers [19]. However, the authors have pointed out that such scale-up methods are only approximations.

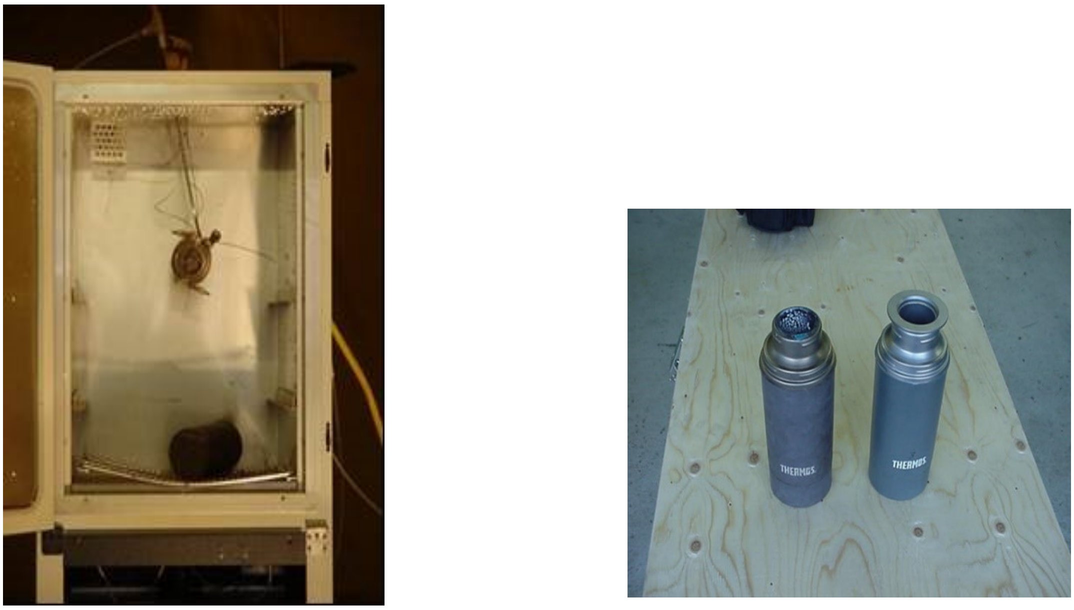

Figure 5 Damage to the Dewar apparatus after an experiment on unsensitised bulk ANWE
Left: damage to the oven. Right: damaged (sheared neck) and undamaged Dewar vessels

3. Deflagration in ANWE

3.1. Ignition

Before a deflagration can take place, a local thermal ignition needs to be established. The ignition process is the transient phenomenon taking place between the initial application of the local thermal stimulus and the establishment of a self-sustained combustion reaction. It is a rather complex process that can lead (or fail to lead) to steady combustion. The "ignition point" is usually taken as the earliest point in time at which, if the initial thermal stimulus is removed, self-sustained combustion would continue to proceed.

Several theoretical models have been developed to attempt to describe this process (see [20, 21, 22], for examples). These models generally consider that once the condensed energetic material locally reaches a certain critical value referred to as "the ignition temperature", it ignites spontaneously. These theories were quite successful for describing the reaction kinetics of energetic materials that ignite promptly. When resistance wires (so-called "hot wires") were used to ignite these types of energetic materials, sharp rises in the wire temperature were observed upon ignition of exothermic reactions in the condensed phase. It was more recently found [23] that ANWEs generally do not behave in such a simple manner.

Figure 6 shows typical signals from a hot wire ignition experiment on an ANWE initially maintained at elevated pressure in an enclosure. The hot wire current (green) is shown to come on (10.57 A) at t=0 and stays on until the wire melts at t_m=11.5 s. A 0.5 mm diameter nichrome hot wire was used. Its resistance was previously calibrated as a function of temperature in a furnace [23]. Using this calibration, the hot wire temperature signal was determined from the measured voltage history across the hot wire, taking into account the constant hot wire current. It can be observed that, in contrast with the sharp temperature increase obtained for other types of energetic materials such as watergels [24] and propellants [25], the temperature increase in the ANWE is very gradual and more complex.

The first part of the temperature curve (up to 250-300°C) is consistent with that of an inert medium surrounding the hot wire [26]. This portion of the curve can be predicted from inert hot wire theory [27]. The point at which the wire temperature starts to deviate from the inert heating curve is termed "the transition point (t_o)". As seen from Figure 6, starting from this point, the curve shows an upward inflexion as the temperature increase accelerates until it becomes nearly exponential. The transition temperature

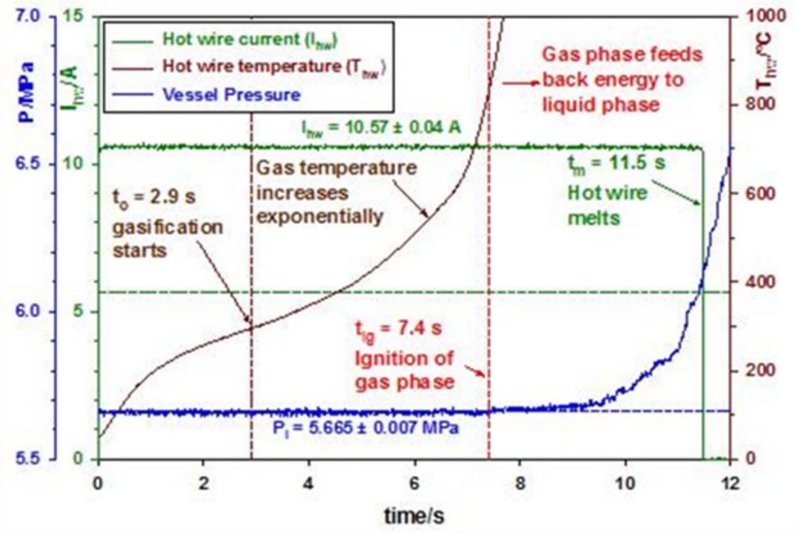

Figure Typical current, temperature, and pressure history for a hot wire ignition experiment on an ANWE

was found to be pressure dependent and it was shown to be related to the vapour pressure of the associated AN solutions [26]. The pressure dependence of the transition temperature could be explained using an energy balance model taking into account the net heat input into the explosive, the heat of vaporization of the AN solution, and the heat of decomposition and/or dissociation of the AN itself [26].

The present interpretation of the localized thermal ignition mechanism in ANWEs is that the heat from the hot wire turns the liquid phase into gaseous products near the hot wire at sufficiently high temperature to start a reaction of the gas species, ultimately leading to an exponential temperature rise reaching the ignition temperature of the gases. Heat from the high temperature burning gases feeds back to the condensed (emulsion) phase and continues the reaction cycle resulting in a self-sustained steady combustion front.

Using the calibration of the hot wire [23], it was possible to calculate the net energy flux delivered into the explosive up to the transition point (e_o at t_o) and the ignition point (e_{ig} at t_{ig}). For a typical AN/SN packaged product (10% water) energies in the following range were found to be necessary: e_o = 51-79 J cm^{-2} and e_{ig} = 140-210 J cm^{-2}. For a typical purely AN bulk product (17% water) the required energies were larger: e_o = 66-101 J cm^{-2} and e_{ig} = 150-265 J cm^{-2} [28].

3.2. Combustion (burning)

In the most common definition, burning involves the reaction of a fuel with the oxygen from the atmosphere. For energetic materials, the atmosphere does not really take part into the reaction as these materials already consist of fuel/oxygen mixtures.

Combustion in a condensed energetic material is the process of rapid exothermic reaction due to the oxidation of the condensed phase. The latter is induced and maintained by the energy delivered by the gaseous reaction products. This gaseous front is generally observed as a flame front ahead of the regressing unreacted condensed phase. In ANWEs, the luminosity of this flame would be expected to be much less intense compared to observations in propellants. In order to become self-sustained, the energy returned to the condensed phase by the gas reaction must be sufficient to overcome the energy losses to the environment and to any endothermic processes. In the case of ANWE, the former is largely controlled by the size of the container while the latter mostly consists of contributions from water vaporization and AN dissociation into ammonia and nitric acid.

The rate of regression of the condensed phase is usually called the “burn rate”. The burn rate *r* is known to increase with pressure and the equation commonly used to parametrize this dependence is called the St. Robert’s equation (1839):

$$r \approx a P^n \qquad (1)$$

where *a* and *n* are correlation coefficients. Therefore, as the pressure increases, the flame zone would be expected to become narrower and to move closer to the condensed phase. If the pressure is decreased, the flame zone would move further away from the condensed phase, thus decreasing the rate of energy feedback to the reaction zone. This would decrease the burn rate up to the point where, if the pressure is further reduced, the flame would extinguish. The pressure at this point is usually termed “Minimum Burning Pressure” (MBP). It has also been demonstrated that because of energy losses due to wall interactions, the burn rate also has a strong dependency on the charge size. Therefore, very significant differences have been quoted for ANWE burn rates at various average pressures and charge sizes [29, 30]. It should however be pointed out that these burn rates are apparently slow enough so that, in most practical cases, the combustion can be easily quenched by a properly sized rupture disc [31].

Clearly, the MBP is a relatively important intrinsic property of each ANWE as it could be used to determine safe operating pressures for ANWE processing and loading by mechanical devices (mostly mixers and pumps). However, in order for it to constitute a useful and conservative parameter, research had to be performed to take into account a large number of physical factors to make it reproducible and independent of the sample size and emulsion viscosity. Such a measurement protocol now exists at the Canadian Explosives Research Laboratory and many of the measured MBP values have been published in the open literature [32, 33]. They varied between 940 kPa (120 psig) for an AN/SN/SP/Al packaged product (7.5% water) and 17.2 MPa (2480 psig) for an AN/CN bulk product (17% water). It should be pointed out that these reported MBP values were measured at room temperature. This was based on the fact that no significant differences could be evidenced when measurements were performed at 20°C or 75°C [34], which would represent a typical transport/loading temperature. However, in order to quantify the effect of much higher temperature more representative of fire engulfment, experiments were also performed at 150°C. In this case, very significant MBP reduction and average burn rate increase were evidenced [35, 36].

4. Detonation

A detonation is a process in which a shock-induced, supersonic combustion wave propagates through a reactive mixture or exothermic compound.

As discussed earlier, two mechanisms already observed in many energetic materials are most probably leading to a detonation in an industrial environment. Under heavy confinement, the gases produced by a steady deflagration may become trapped. This would inevitably lead to a rapid pressurization and, from Equation (1), to an acceleration of the burning rate. In some cases, the burning rate becomes so high that pressure pulses are generated at the burning surface, leading to the formation of a supersonic detonation front [37]. This is the so-called deflagration-to-detonation transition (DDT) process. An ANWE undergoing this process would exhibit an appreciable time delay between the ignition of the deflagration and the onset of the detonation. Therefore, if fast venting during the early stage of deflagration can be achieved by the use of devices such as rupture discs, an efficient protection against DDTs in ANWE [31] may be obtained. Moreover, experiments have shown that the development of a DDT, under normal conditions of use, would be unlikely in water-based explosives that are void sensitized [38, 39].

In the second mechanism, initiation of detonation in ANWEs may result from the impact of high-velocity projectiles. This has frequently been postulated [40, 41] as a mechanism in various accident scenarios involving fire and subsequent detonation of explosives. Detonation may also result from the explosion of process equipment, sending energetic shrapnel into nearby stocks of ANWE possibly held at abnormal high temperature (fire engulfment). This initiation mode is often termed “shock-to-detonation transition” (SDT). In this case the shock wave induced by the impact of the projectile travels into the explosive and compresses it locally to very high temperature causing very fast exothermic decomposition of the ingredients. This accelerates the shock wave up to a point where it reaches a supersonic velocity, which generates a detonation wave [37].

The shock sensitivity of ANWEs is normally controlled by the introduction of small cavities or bubbles (glass or polymeric microspheres, gas bubbles) into the explosive. Ignition results from the adiabatic compression and the jetting phenomenon occurring during the asymmetric collapse of these voids [42]. Even if these cavities are not deliberately introduced, gas bubbles are always present in an emulsion maintained at elevated temperature due to water evaporation and AN dissociation. Since the density of these voids is expected to vary significantly with temperature, the critical fragment velocity at temperatures corresponding to ambient (20-30°C), process conditions (80-100°C) and fire scenarios (boiling emulsion) is expected to vary widely.

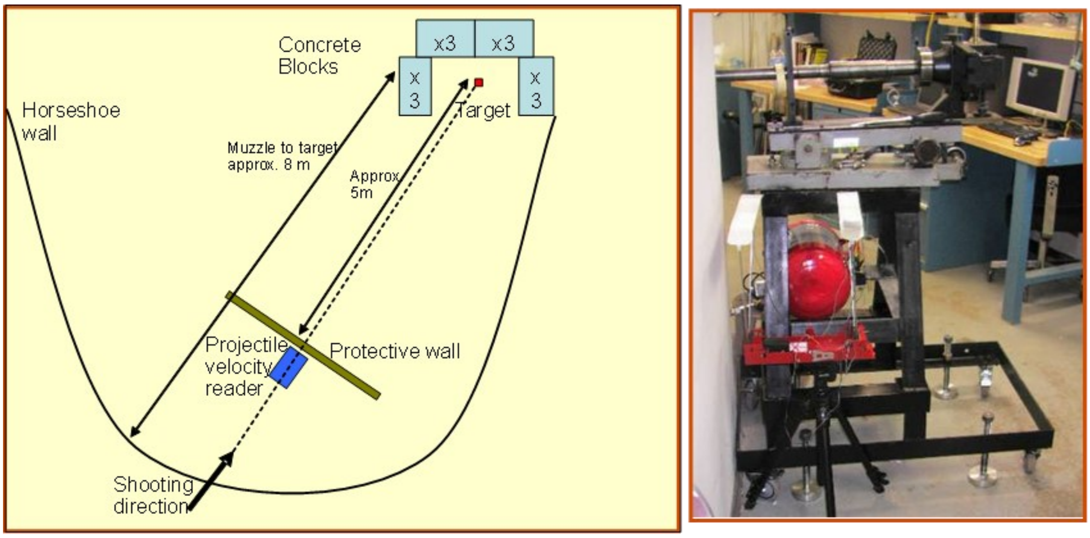

Figure 7 Left: Shooting geometry for projectile impact experiments; Right: Universal receiver mounted behind horseshoe wall

Such high-velocity impacts have been simulated at the Canadian Explosives Research Laboratory by shooting bullets of various calibers and velocities at emulsion targets of about 100 g contained in heated aluminum cylinders [43, 44]. The experimental arrangement for this work in shown in Figure 7. The target was housed in an open air horseshoe-shaped concrete barrier. Shooting was performed from behind the concrete wall using a universal receiver with 5.7 and 12.6 mm diameter brass right cylinders. In these tests, the projectile velocity required to obtain detonation of the sample 50% of the time (V_{50}) was measured through repeated measurements. From these measured V_{50} values, equivalent critical energies (E_C) were extracted using a simple analytical model [44]. As expected, results of tests conducted at ambient (20°C) and process (90°C) temperatures have demonstrated increasing shock sensitivity as a function of temperature.

5. Conclusion

The above description demonstrates that much information and understanding has been gained, in the last two to three decades, on the thermal explosion, deflagration, DDT, and SDT hazards of ANWEs. However, more research is still required on some of these aspects. It is especially noted that published data on the likelihood of DDTs in ANWE systems cannot easily be found and, therefore, more documented research would be helpful for hazard quantification. It should also be realized that most tests on ANWEs have been conducted on freshly manufactured products. It has often been pointed out (see [5] for example) that the effects of ageing under adverse conditions may lead to more hazardous mixtures than the original ANWE. This has often been postulated to explain root causes of accidents occurring in manufacture, transport, and storage.

In order to better understand certain accident scenarios, it would be advisable to experimentally simulate the damage caused to ANWEs exposed to specific physical conditions and then examine their response to the various stimuli described in this paper. Experience dictates that, even without much confinement, a fire in an ANWE manufacturing facility containing a very large inventory of such explosives can become extremely critical and can lead to the initiation of a large-scale detonation [1]. Contamination with incompatible chemicals and plant materials would strongly enhance the probability for such an event. Therefore, it is recommended that establishing compatibility over typical manufacture, handling, and storage time scales should be done on a more systematic basis.

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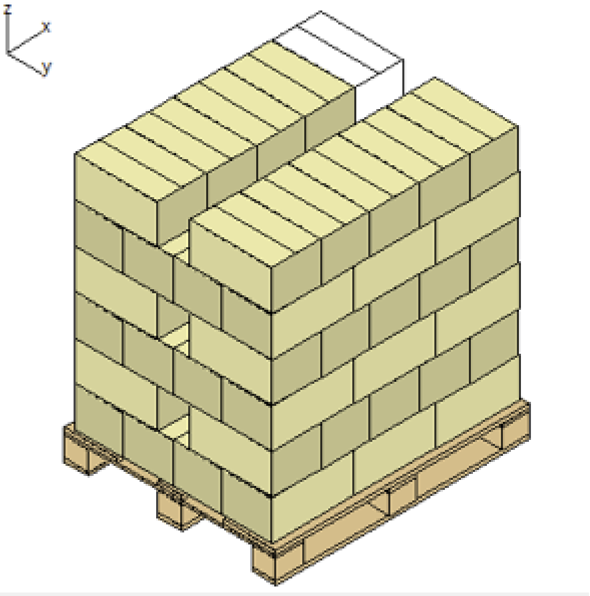
Did you know that - - - ?

Did you know that pallets can be an important issue in the storage and transport of explosives? They are sometime overlooked but are critical to the overall logistics of explosives both on and off the plant site. Often flimsy and not fit-for-purpose pallets are used as well as poor construction methods, of product on pallets, are deployed such as overhang of packaging over the pallet base. Poor pallet construction or condition could present sharp objects that could puncture the packages to be transported. Incorrect forklifting of pallets loaded with explosives can create very serious unsafe situations. Here are some simple principles that have proven over the years to be useful in the construction and operation of pallet loads:

1. Hardwood pallets should be the preference over other options including compressed wood. The use of nails should be minimised as far as practical and all nails should be sealed off. Pallets pads should be used between pallet base and product load to offer further protection from any possible projections from the pallet base into the product. Plastic pallets could be an option provided consideration is given to the fire-retardant additives to its construction.
2. Pallets should be four ways rather than two ways for forklift accessibility. Forklift drivers should be properly trained and licensed
3. The product footprint should always be equal or less than the pallet base to avoid any overhang of product.
4. Product cases should be loaded on the pallet in brick wall (see pic) formation to provide integrity and robustness to the pallet as a unit load. Any gaps in product build on pallet should be filled with “inert fillers” to provide integrity to the pallet load. Where possible some form of glue should be used between each layer of cases to provided further strength to the pallet load. If required pallet pads can be inserted in between layers to spread the load evenly and prevent crushing of packaging. Instability of drums should be considered when constructing the pallet. Package Orientation should always be followed when constructing a pallet.
5. Lashing of product (cases or drums or bags) should be constructed in a manner in which the lashing (straps etc) do not damage the packaging during transit. Pallet corners / edges could be deployed to offer further protection to the unit load.
6. Stretch wrapping should commence from the base of the pallet to encompass the entire load including the top of the load. The numbers of layers of stretch wrapping need to be adequate to maintain the integrity of the pallet.
7. Dangerous Goods Labelling should be visible on all four sides of the finished pallet – appropriate over labels should be deployed if required.
8. Multiple Stacking of pallets of explosives are not recommended – if required, the package compression, method of filling etc need to be tested before multiple stacking of pallets are considered.



Submitted by Maurice Bourgeois/Brian Devaraj

For further information on Pallets for Explosives you may contact the Expert Panel.

Emulsification System Safety Test

by
Jiří Těšitel - Explosives Research Group
Zdenek Vybíhal - Explosives Research Group
Lubomír Vacek – Explosives Research GroupLaboratory of Safety Engineering, Research Institute of Industrial Chemistry, Explosia a. s., Pardubice – Semtín, Czech Republic

Introduction

The Research Institute of Industrial Chemistry (VÚPCH), founded in 1954 is the part of Explosia a.s., Pardubice – Semtín, Czech Republic.

This institute ensures research and development in the field of explosives and ammunition not only for Explosia a.s., but also for other partners within the Czech Republic and abroad.

Apart from research and development, whose results are intended both for industrial applications and the military sphere, VÚPCH offers services in the field of analytical chemistry, testing and safety engineering for explosives and ammunition, small tonnage production of new energy materials and special explosives and the production of pyrotechnic components for aircraft rescue systems.

Opening

It is a well-known fact that vigorous stirring of emulsions brings about internal phase droplet size reduction and viscosity and temperature increase. This occurs in the emulsification equipment during the manufacture of explosives. So a situation where the raw material feed stops but the continuous emulsification system continues working is potentially hazardous. This is why we decided to subject our emulsification system to a test in 1995(1).

Emulsification system

The continuous emulsification system, which is a proprietary product (Patent CZ No. 286901), consists of a cylindrical vessel with a double jacket, accommodating a hollow cylinder-shaped stirrer with holes in its base . The incoming materials, i.e. water phase and the oil phase, are fed to the stirrer centre. The perforated stirrer bottom acts as a centrifugal pump, driving the incoming material mixture into a narrow gap between the vessel wall and the stirrer wall, where the emulsification process takes place. The stirrer design makes for repeated passage of the water/oil mixture through the narrow gap between the vessel wall and the stirrer. The emulsification system safety test simulated the condition with the system full of the emulsion; incoming material feed was stopped while the system drive continued working.

Test design

18 kg of the emulsion was added to the emulsification system. The emulsion consisted of:

Ammonium/sodium nitrate	77.4%
Water	13.0%
Oil phase	5.6%

A 2cm gap was left above the emulsion to enable the mixture to be aerated during the stirring process. . The emulsification system stirrer speed was set at 1400 rpm.

The parameters measured during the test included the drive input power, temperature in the system bottom and temperature in the gap between the vessel wall and the stirrer wall. The whole system was placed in a trench and covered with soil.

Three different scenarios were considered conceivable in the test:

1. The emulsion viscosity will increase during the stirring process, resistance will grow to the extent that the drive will be unable to overcome it and the motor will stop.
2. The emulsion will break down, viscosity will drop, less heat will be produced by friction, heat will be more easily removed from the system, and the temperature will not rise any more.
3. The amount of heat produced by friction is so large that not all of it can be removed and the temperature will increase to a point where exothermic reactions are initiated.

The test took 48 minutes, during which water evaporated from the emulsion and condensed in the driving motor, whereupon the drive failed and the test was terminated. The material that was found in the emulsification system after the test included a mixture of molten oxidants and the oil phase with a very small amount of water, which solidified to give a hard brittle material on cooling.

The plots on the next page show the development of the emulsification system temperature and of the emulsion temperature in the gap between the vessel jacket and the stirrer over time.

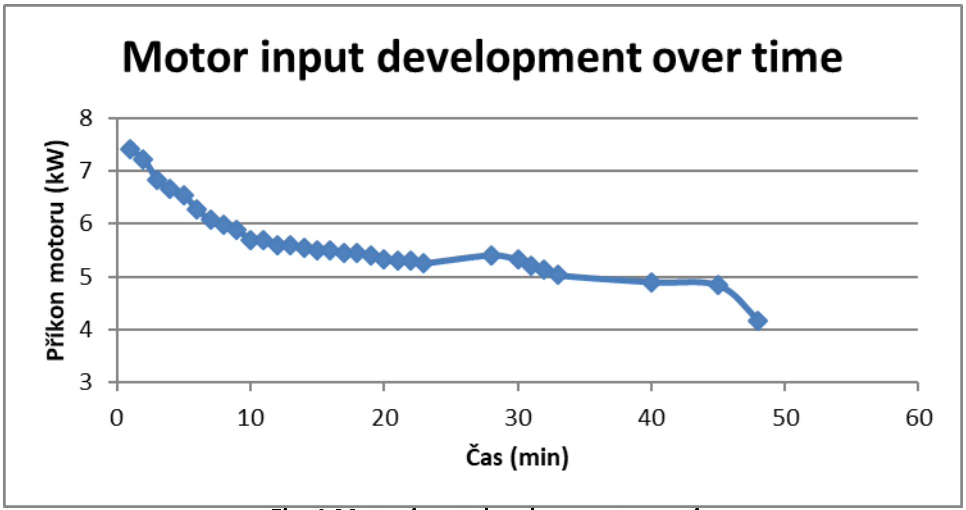


Fig. 1 Motor input development over time

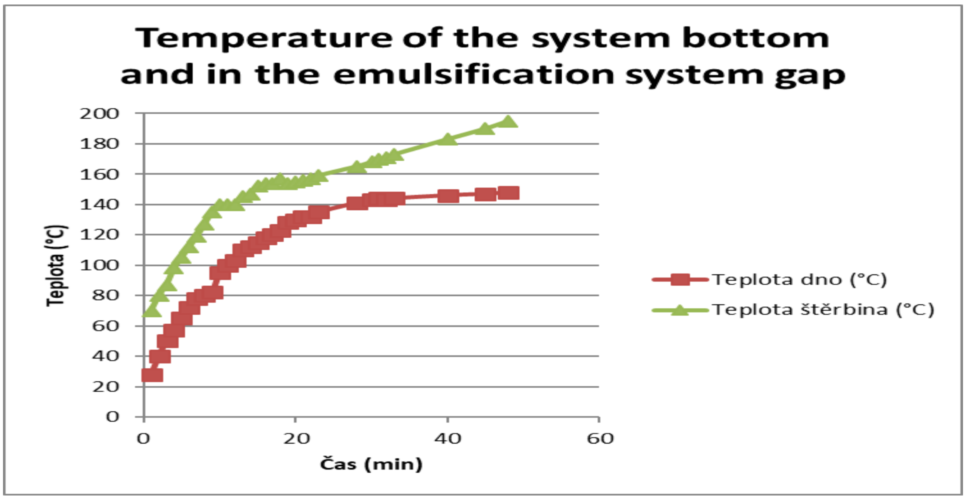


Fig. 2 Development of the emulsification system bottom temperature and of the emulsion temperature in the emulsification system gap over time

The plots demonstrate that the emulsion temperature in the emulsification system gap increased rapidly up to 140°C, after which the emulsion broke down and water started evaporating. The temperature of the (non-doubled ????) emulsification system bottom started stabilising after the emulsion had broken down. The heat generated by friction in the gap, however, was too high to be completely removed (the emulsification system was doubled but no water was present in the duplicator) and the temperature continued to rise.

The system failure stopped the test just below the temperature limit above which exothermic reactions could be initiated. The temperature reached (195ºC in the gap) was nearly at the limit for triggering exothermic reactions (220ºC) in the ammonium nitrate-fuel system as found by Wollert-Johanson(2) and confirmed by differential thermal analysis.

So, the worst-case scenario from among those outlined above actually occurred: the emulsion broke down, the water nearly completely evaporated and what remained was a hot nitrate-fuel mixture the temperature of which continued to increase. Exothermic reactions could follow. This finding is alarming.

The emulsification system safety test, performed in harsher conditions than the normal operation conditions, on the one hand, demonstrated the system's inherent safety. The system is unable, in the conceivable emulsion aeration conditions (air gap above the emulsion) in which the heat generated by friction inside of the emulsion fails to be removed completely by the heating circuit water, to bring the emulsion to exothermic reactions within nearly 1 hour. On the other hand, the test demonstrated the potential hazardousness of this condition.

It is virtually impossible for the conditions leading to the initiation of exothermic reactions in real operation to be established (if malice or gross negligence are disregarded).I don’t think we can say this on the basis of this one test where the drive failed. What would have happened if the drive had not failed or a different drive system was used? However, it is interesting to see how the energy input to the system quickly starts to increase the temperature of the product in a no-flow situation.

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The importance of adapting an operator’s work station to his/her physical characteristics and personal preferences.

by

Andrea Sánchez Krellenberg

1.Introduction

The purpose of this article is to highlight the risks associated with an employee’s inadequate workstation area setup due to his or her physical characteristics and personal preferences. This has been brought to attention due to an accident reported by Austin Detonator s..r..o. involving a lab operator.

Figure 1. Workplace arranged for a right-hander.

Figure 2. Workplace arranged for a left-hander.

The incident took place in a lab station where the operator was handling **lead azide** which happened to initiate thus shattering a glass container into bits and dust causing lacerations to the operators left hand and forearm.

Discussing the underlying causes and contributing factors it was highlighted that the operator used an antistatic wrist strap (as required in the operating procedure) and that she had arranged the workplace for her convenience (Figure 2) since she was left-handed. The investigation report indicated as a plausible scenario that the operator might have knocked over or tipped the glass container with the antistatic wrist strap which then supplied sufficient energy for the LA to initiate.

This accident and findings highlighted the need to evaluate not just the workplace setup itself, but also to employee’s individual characteristics and, as appropriate, adapt the workstation to the individual preferences to ensure the job can be carried out safely and properly.

2. Identify the situation at your site and take actions:

To prevent and control this kind of risk, take the following essential measures when applicable:

2.1.When assessing hazards and associated risks of the task, pay special attention to:

- Workstation layout according to the operator's physical and personal specifics.
- PPE is adequate for both the activity and for the person carrying out the activity.
- Workstation space and mobility
- Material and equipment are appropriate for the task and the employee working in the area.

2.2.Use existing management tools or introduce additional ones, such as:

- **Safety Preventive Observations/Job Cycle Checks:** Observations and inspections are conducted for the continuous workplace risk management. When verifying the operator's performed actions in their work position, special attention must be paid to evaluate the adequacy of the workstation to the distinct characteristics of the person working in that area (whether he/she is left/right handed, short/tall, and physical size). As appropriate, the workstation should be adapted to the specific requirements of the operator.

- **New Project/Pre-start Safety Reviews**: When considering new project or changes, a safety review—before the activity starts—must be performed bearing in mind the personnel who will be performing the job and their physical and distinct characteristics for the design or adaptation of the work area.

2.3.Management actions:

- **Review Standard Operative Procedures** to include a specific warning to consider the operator's individual characteristics when assessing the task's potential hazards.

- **Train** workers on hazard detection and **encourage them to communicate** any personal characteristics that could affect the risk assessment of his/her position.

A retrospective view on human and machines in our industry

by

Colin Wilson

There is no denying that technology has disrupted all industries bringing dynamic changes in how things are done and certainly shaping the working environment in a way never anticipated. The saying "disrupt or be disrupted" applies strongly here.

In our industry where safety is of paramount importance, we have to constantly maintain a high standard and follow procedures set by our predecessors. Newly developed technologies need to be supported by continuous staff training in the manufacturing environment for consistency and to mitigate accidents in plants. It is important that we never forget the basics of explosives manufacture.

I have been working in the explosives manufacturing industry for over 30 years and I have witnessed many systems and standards change. At times, I long for the "good old days" when people ran the plants and not machines. These days people are relying heavily on machines, while in the past you would consult with extensive knowledge and expertise for direction and guidance. This was very comforting to me. It felt safe that Johnny X was running the plant instead of a state-of-the-art faceless machine.

However, after much introspection, I realised that this thinking places you in a position where, if you cannot adapt to change, you will be replaced!

The explosives manufacturing industry, along with all other manufacturing industries, is changing at a rapid pace and this change will become more dramatic as time progresses. We have developed and will continue to develop safer products and manufacturing methods. Advances in autonomous technologies are constantly being introduced, becoming a major component in our plants and will replace the traditional manufacturing structures. Explosives manufacture will not be immune to disruptive exponential technological changes.

The questions that we need answered are:

- How will this impact on our ability to safely manufacture explosive products?
    - ◊ I believe, as an industry we have already become a lot more sensitive around what we can and cannot do. There are many practices that were condoned in the past that are totally unacceptable today. We have not only introduced new technologies and safer products but extensive improvements have been made in the softer areas, such as recruitment criteria, training as well as understanding and assessing risks.
    - ◊ As manufacturing technologies are improving so are management technologies. Safety management systems are electronic, online and updated in real-time.

  - Training is becoming more globally accessible online and content is detailed, updated and immediately available.

- Can we adapt to these changes?
  - Many explosives companies have a rich heritage extending over many decades. Those that have survived have experienced change, adapted to it and will continue to adapt. I am sure the questions we are asking now about the loss of expertise have been asked before. Have we lost the expertise of the past? I think so. People have come and gone for decades, but I believe that we have developed new expertise and will continue to nurture and adapt this knowledge.
  - A change in recent years has been brought on by new regulatory requirements. Gone are the days when SHE manages were seen as minor roles on the manufacturing plants. These have become critical specialist roles with highly skilled individuals using technology to ensure on-going compliance.
  - We are all in many ways already adapting to these changes and have all wittingly or unwittingly, recently used some disruptive technology in our day-to-day activities.

- Have we lowered our standards and increased our risks because we are using machines to monitor or in some cases run our plants?
  - I believe that these technologies can improve manufacturing operations.
  - It has been proven that any repetitive task, can be done faster, safer and more accurate using a machine.

However, I don't believe we will solely rely on these technologies and safer products to prevent accidents from occurring. Our human capital will always play a key role in ensuring our manufacturing process doesn't harm people, equipment and the environment.

Perhaps the success of the future is fashioned on the collaboration between man and machine. We will need to develop new expertise but retain the old knowledge. As an industry our resilience and ability to adapt to change has enabled our very existence. Change going forward is inevitable and we will embrace it!

Explosives & Dangerous Goods Vehicle Load Securing

By

Brian Deveraj

Following on from the article on Pallet Safety in the previous Newsletter, securing explosives & dangerous goods loads on trucks and other modes of transport is equally important and critical to delivering product from plant to customer safely. Loose loads can be dangerous and sometime fatal. It has been estimated that up to 25% of accidents involving trucks can be attributed to inadequate cargo securing.

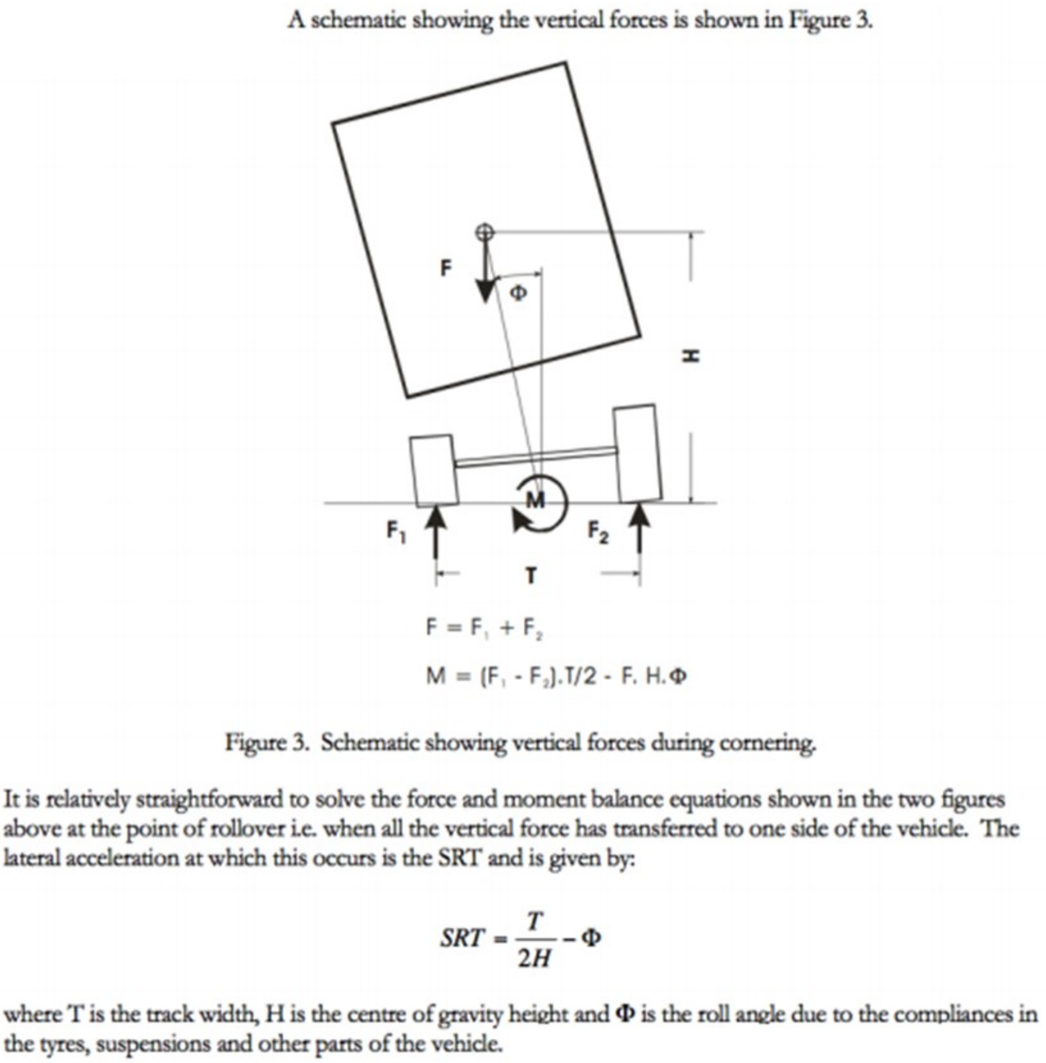
Product that is incorrectly secured can result in severe accidents and lead to either loss of cargo, loss of lives, loss of vehicle or result in serious environmental hazards. You can also get damage to cargo packaging with consequent leakage/spillage inside a closed vehicle – not so nice with dynamites and wet PETN, Azide etc.Here are some simple tips to consider:

Dunnage: There are several techniques depending on the type of packaging being loaded that can be deployed to fill voids and thereby prevent cargo from shifting due to vehicle movement.

Lashing & Strapping: While there are several methods of restraining a load, lashing the cargo with lashing straps or chains (depending on the type of cargo being transported) is one method, with an aim to minimise shifting during transit. The Coefficient of Friction between the package and the vehicle floor play an important role in the type of lashing mechanism that is to be used. Expert technical advice should be sought if required. Where Shipping Containers are used, Twist Locks must always be deployed and locked.

Roll Over Risk: The Centre of Gravity of a given load should be in accordance with local regulations and certainly within good practice norms. The Static Roll Over Threshold (SRT) should be calculated where necessary to ensure it is within recommended limits. This will ensure the transport vehicle does not pose any roll over risk during transit.

Note that a minimum SRT value of 0.35g does not guarantee that the vehicle cannot rollover in the wrong circumstances. However, at SRT values below 0.35g, trucks are considered to have insufficient margins of safety to allow for driver error. At higher values, the margin for error increases. In some OECD countries, it is considered advisable that all vehicles have a minimum SRT of 0.35g, while those carrying Dangerous Goods have recommended minimum SRTs of 0.40g (or 0.45g for liquid tankers). Most countries do not have clear rules on SRT to prevent truck rollover.



A schematic showing the vertical forces is shown in Figure 3.

$$F = F_1 + F_2$$

$$M = (F_1 - F_2).T/2 - F.\ H.\Phi$$

Figure 3. Schematic showing vertical forces during cornering.

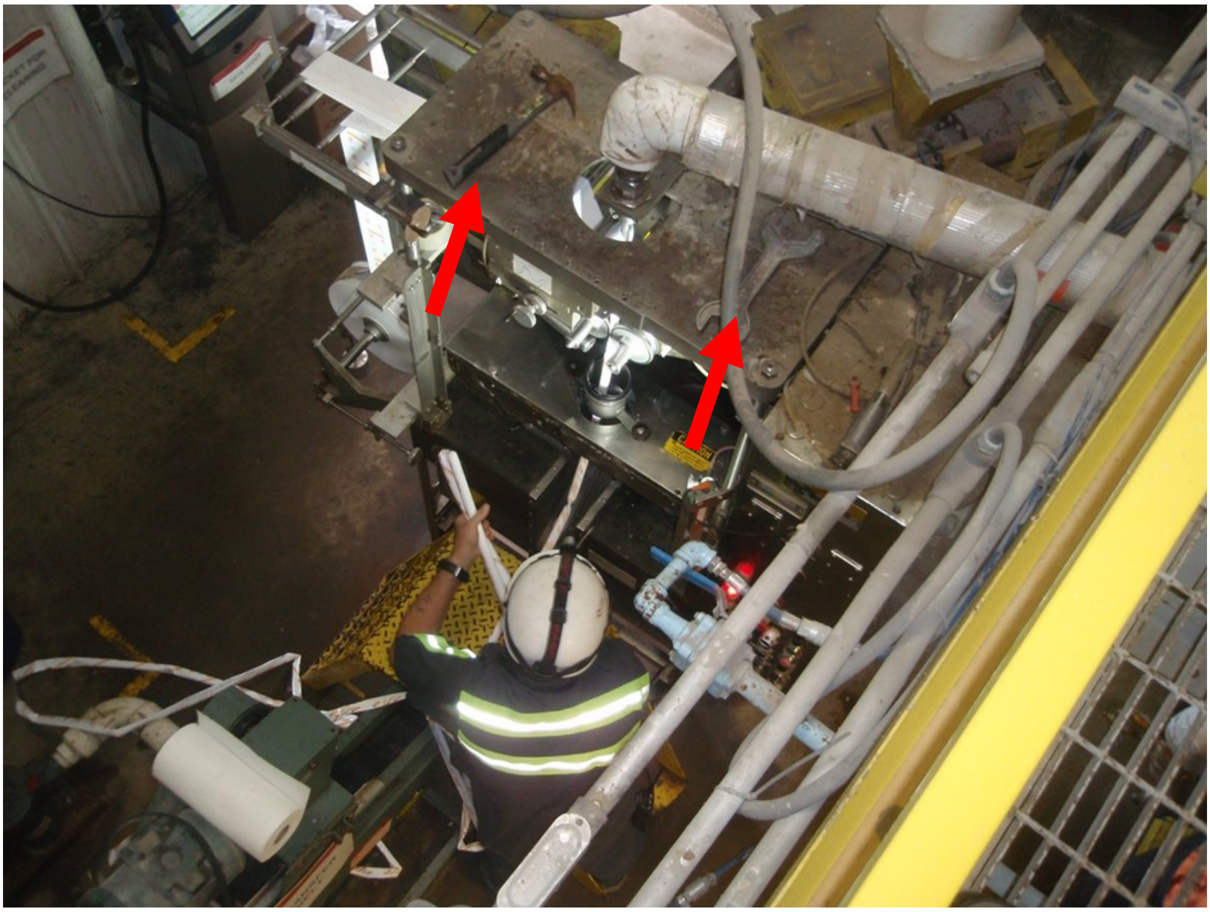
It is relatively straightforward to solve the force and moment balance equations shown in the two figures above at the point of rollover i.e. when all the vertical force has transferred to one side of the vehicle. The lateral acceleration at which this occurs is the SRT and is given by:

$$SRT = \frac{T}{2H} - \Phi$$

where T is the track width, H is the centre of gravity height and Φ is the roll angle due to the compliances in the tyres, suspensions and other parts of the vehicle.

All of the above measures should be deployed to ensure a properly restrained load will not dislodge in the event of severe braking, swerving, or cornering. Bear in mind that a heavy load is just as likely to fall as a light load will, as the same g forces are acting on both loads.

TOPICAL PICTURES



Two tools left by maintenance personnel after completion of work. This could indicate issues with the local Permit to Work procedure as follows. Maintenance personnel are required to check the workplace at the completion of work that all tools, spare parts etc have been removed from the work area before handing the plant back to operations. The responsible Plant Supervisor is required to check the workplace before accepting the plant as fit for resumption of normal operation.

Pictures like these speak a thousand words-please send your pictures of good and bad practises ,as you can see they are placed anonymously!

MANAGEMENT OF CHANGE (MOC)

by

Stephen Caldwell

Unexpected or un-assessed risks can be introduced when changes are made without adopting a formal review and approval procedure.

Common problems with changes include:

- Procedures for change control are overlooked due to time pressure or lack of awareness.
- Temporary fixes are not assessed as changes and often become permanent due to time and resource pressure.
- Downstream or upstream consequence are not properly assessed.

- Changes which appear to be trivial are not carefully evaluated.
- The appropriate subject matter experts are not consulted before changes are made and as a result risks are not appropriately assessed.
- Changes to control systems and in particular software are not fully evaluated.
- Development work carried out by R&D or Technical where responsibilities are not clear or not well defined.
- Scale-up of an existing process may introduce unexpected effects to the process.
- The impact of product, process packaging, storage or transport changes to the final customer's operations are not fully assessed.

Objective:

Controls are needed for proposed changes or modifications to plant, processes, products, materials. All changes whether permanent or temporary, should be made formally, legally and responsibly. Systems and documentation related to changes need to be adequately updated to reflect details of the changes. These could include Operating Instructions, P&ID, Maintenance Schedules, Training etc.

Process

The MOC process goes through the following steps:

- Record
- Analyze
- Approve (or not)
- Implement
- Check effectiveness

Responsibilities:

All managers (operations, technical, engineering, distribution and sales and marketing) are to ensure that the requirements of the MOC Control System are met. Managers are responsible for informing all site personnel and outside contractors about the requirements of the MOC System.

A change may be suggested by any person including an operator but it is not expected for them to manage and implement the change through the system. An initiator of a MOC must be appointed and must be a competent person capable and qualified to oversee and manage the implementation of the change. The actions arising from a proposed change may be different for each case. These actions must be identified, documented and assigned to various disciplines for completion.

All authorities signing off on a MOC must apply their minds to the consequences of the change and stipulate any requirements and conditions necessary to implement the change. This may include the requirement for a hazard and operability study and/or risk assessment.

Appendices:

Appendix 1: Typical MOC form

Appendix 2: Typical SHE Checklist.

Appendix 3: Typical Approvals list.

Appendix 4: Examples of changes where an approved MOC may be required and actions arising from MOC's

Appendix 5: An audit protocol for MOC system

Appendix 1

Company Logo	MANAGEMENT OF CHANGE		Initiator:	
	Building/ Site		Signature:	
	Registration number		Date	

Trial Period:	From:		To:	
Permanent Change:	Start date:			

Title:	
Present position:	
Proposed position:	
Benefits:	

Legal approval required?	Yes	No	Hazard and Operability Study required?	Yes	No	Risk Assessment required?	Yes	No

Support Signatures	Persons to be informed	Actions Arising from change

Approval before implementation:		Sign off on completion:	
Explosives Manager		Explosives Manager	
Signature:		Signature:	
Date:		Date:	

Appendix 2

SHE CHECK LIST

	Yes/No	What problem has been created which may affect plant or personnel safety and what action is recommended to minimise it?	Signed and Dated
1. Is there an increased risk of ignition of explosion due to friction or blows?			
2. Is there an increased confinement of explosive materials?			
3. Is there an increased risk of transition deflagration to detonation due to the explosives bed depth?			
4. Is there an increased risk of an explosion propagating from one area to another?			
5. Is there an increased exposure of explosive material to direct sunlight?			
6. Is it necessary to remove or decontaminate out of use plant – or alternatively to mark it clearly?			
7. Is there any risk of explosion hazard (Vapour/Gas/Dust/Explosion)?			
8. Is there an increased fire risk?			
9. Is there danger from: High or Low Temperature? High or Low Pressure?			
10. Is any material based on volatile petroleum products?			
~~11~~ Are any chemical or physical hazards being introduced			
12 Is Asbestos involved?			
13 Have noise levels increased ?			
14 Is a hazardous substance Assessment needed?			
~~15~~ Are there risks from Ionising Radiation?			
16 Is a manual handling assessment needed?			
17 Is a display screen assessment needed?			
18 Does the modification introduce heat stress?			
19 Will the modification result in any increase in waste generated by the plant during normal or abnormal running conditions?			
20 Is there any increased electrical risk (eg. Static electricity, earthing)?			
21 a. Has an electrical classification been carried out? b. Is new electrically operated equipment rated for use in classified area?			
22 Is a "fail-safe" condition established?			

23 Are the materials of construction and design of hardware consistent with the standards of existing plant?			
24 Is any alteration required to the guarding of machinery?			
25 Has any additional obstruction been introduced?			
26 Is there restricted access to existing equipment for operation, inspection or maintenance?			
27 Is a change to a programmable electronic system involved?			
28 Are any modifications necessary to: • Existing Drawings • Operating Instructions or Working Regulations • Manufacturing Methods • Maintenance Schedules • Explosive Licences • Fire Certificates • Critical Task Checklist			
29 Is it necessary to consult • Safety Specialist • Occupational Health Specialist • Occupational Hygienist • Environmental Specialist • Fire/Security Services • Technical Support Group • Analytical			

Checked by:

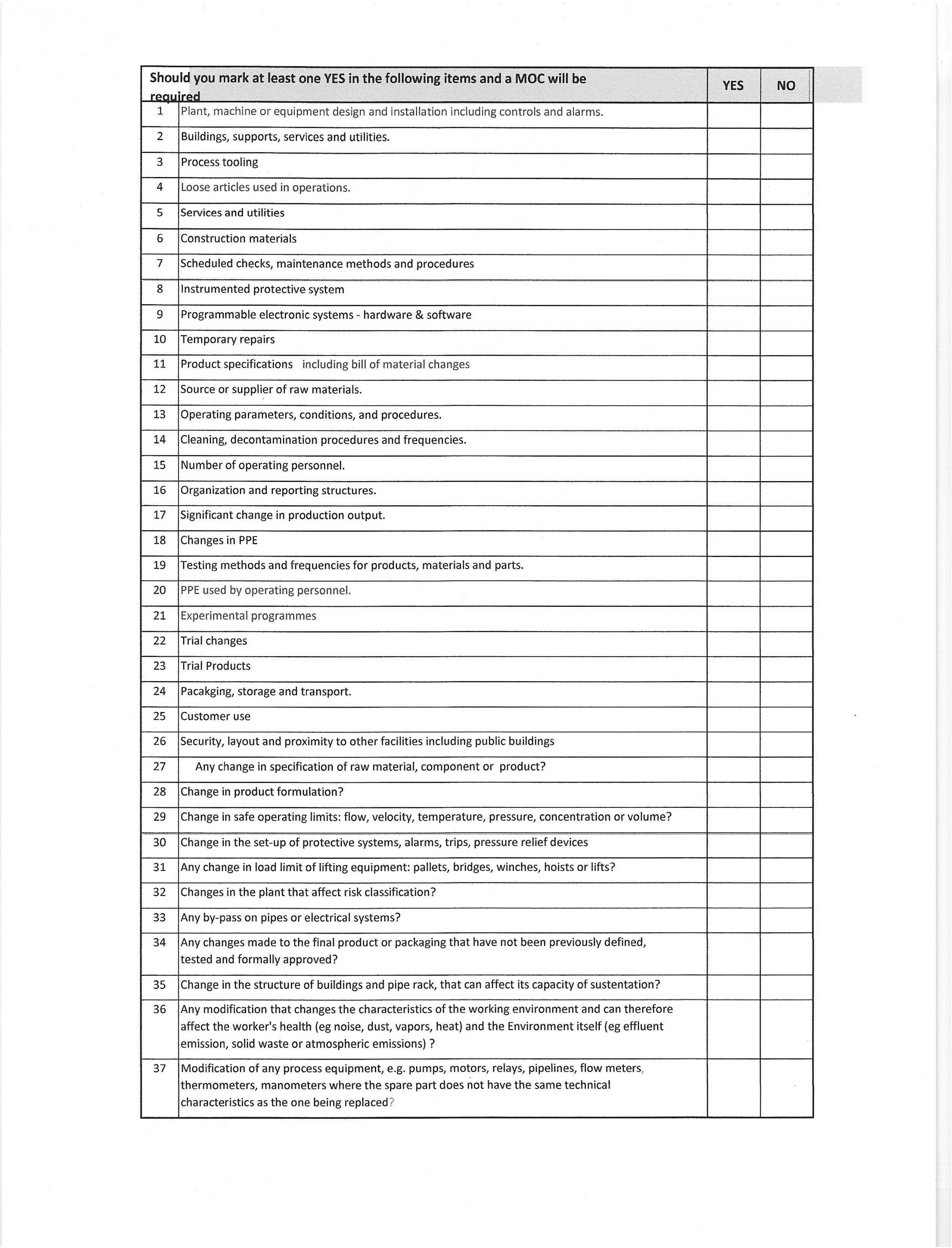
Date:

Appendix 3

APPROVALS

	Signed	Date	Remarks **(N/A if not applicable**)
Design completed in accordance with specifications, codes of practice and safety assessment requirements.			
Construction completed in accordance with design.			
Equipment tested as specified.			
Modified plant accepted.			
Plant copies of records have been amended:			
Operating Instructions			
Working Regulations.			
Manufacturing Process Records			
Engineering Drawings			
Wiring Diagrams			
Plant Line Diagrams			
Computer Database (2 copies)			
Plant Unit/ Item List			
Engineering Piping and Instrumentation diagrams			
Register of Intrinsic Safe Equipment			
Plant and Swtichroom Label's & Motor Control Room Centre Register			
Maintenance Schedule			
Notification of amendments sent to Design Office Manager:			
Engineering Drawings			
Wiring Diagrams			
Line Diagrams			
Safety Assessment Reviewed			
Risk Assessment Reviewed			
Hazardous Substances Assessment Reviewed			
Local Plant Consents Reviewed			

Appendix 4



Should you mark at least one YES in the following items and a MOC will be required		YES	NO
1	Plant, machine or equipment design and installation including controls and alarms.		
2	Buildings, supports, services and utilities.		
3	Process tooling		
4	Loose articles used in operations.		
5	Services and utilities		
6	Construction materials		
7	Scheduled checks, maintenance methods and procedures		
8	Instrumented protective system		
9	Programmable electronic systems - hardware & software		
10	Temporary repairs		
11	Product specifications including bill of material changes		
12	Source or supplier of raw materials.		
13	Operating parameters, conditions, and procedures.		
14	Cleaning, decontamination procedures and frequencies.		
15	Number of operating personnel.		
16	Organization and reporting structures.		
17	Significant change in production output.		
18	Changes in PPE		
19	Testing methods and frequencies for products, materials and parts.		
20	PPE used by operating personnel.		
21	Experimental programmes		
22	Trial changes		
23	Trial Products		
24	Pacakging, storage and transport.		
25	Customer use		
26	Security, layout and proximity to other facilities including public buildings		
27	Any change in specification of raw material, component or product?		
28	Change in product formulation?		
29	Change in safe operating limits: flow, velocity, temperature, pressure, concentration or volume?		
30	Change in the set-up of protective systems, alarms, trips, pressure relief devices		
31	Any change in load limit of lifting equipment: pallets, bridges, winches, hoists or lifts?		
32	Changes in the plant that affect risk classification?		
33	Any by-pass on pipes or electrical systems?		
34	Any changes made to the final product or packaging that have not been previously defined, tested and formally approved?		
35	Change in the structure of buildings and pipe rack, that can affect its capacity of sustentation?		
36	Any modification that changes the characteristics of the working environment and can therefore affect the worker's health (eg noise, dust, vapors, heat) and the Environment itself (eg effluent emission, solid waste or atmospheric emissions) ?		
37	Modification of any process equipment, e.g. pumps, motors, relays, pipelines, flow meters, thermometers, manometers where the spare part does not have the same technical characteristics as the one being replaced?		

Appendix 5

An audit protocol for MOC system

1. Is there a standard for MOC that complies with at least regulatory requirements?
2. Is there a training programme for **all** personnel?
3. Does the training include contractors?
4. Are records of approved or rejected MOCs filed and maintained for the life of the plant or process involved?
5. Are records of in progress MOCs retained and are these accessible?
6. Is the MOC system being fully and correctly implemented?
    a. Are all appropriate approval authorities identified on the MOC form?
    b. Are MOCs supported and approved by the necessary authorities?
    c. Are all required actions clearly described, assigned, a due date allocated and accepted?
    d. Are changes monitored and managed as per the actions or requirements stipulated?
    e. Is associated documentation correctly handed over to the operating personnel?
    f. Are actions required before implementation of MOCs completed and signed off?
    g. Are actions required after implementation of MOCs completed and signed off in reasonable time?
    h. Are MOCs correctly closed off?

Inspection guide for the auditor

Check

- Records of completed MOC forms correct filled in – all sections completed and consistent with the procedure
- All MOC reference numbers are accounted for (e.g. rejected MOCs should still be in the file)
- If possible examine an in progress MOC– check that MOC has been registered, is correctly filled in, and that the person/s to whom actions or tasks have been assigned are aware of these requirements.

The MOC itself is not an assurance that accidents will not happen. It is necessary that all those involved perform their tasks with discipline.

ARTICLES FOR NEWSLETTER

This is a reminder that through the Newsletters we share knowledge in the areas of Safety, Health, Environment and Security pertaining to the Explosives Industry. SAFEX thus call on all members to submit articles on these subjects within their own companies and countries. **The deadline for articles for the December Newsletter is 10 December 2017 and I look forward to your support** .

SAFEX thanks the following authors for their valuable support:

- **Brian Deveraj-Expert Panel**
- **Maurice Bourgeois –Expert Panel**
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- **Jackson Shaver –Special Devices Inc.**
- **Richard Turcotte et al– CERL**
- **Jiří Těšitel et al-Explosia a.s.**