Case Study 5 – Safety Relief Plant-Wide Study

Due to changes made in the product slate differing from its original design, a batch-operated epoxy resins plant hired this consultant to evaluate its present safety relief systems in accordance with OSHA standards. The original plant design included only a few products that were based in acetone solvents, but later incorporated many more solution-based epoxy products that contained an array of different solvents having various solvent properties. Since the relief systems may respond differently to the various solvents, a thorough investigation was necessary to determine if relief system modifications were required.

The objectives of the evaluation:

- Provide documentation for location files consistent with OSHA requirements
- Recommend corrections to any relief deficiencies identified by the unit process hazards analysis (PHA) or this evaluation
- Remain consistent with existing relief system plant inspection and maintenance program

The evaluation matrix was very complex and multidimensional, consisting now of 23 different solvents with products produced in multiple batch reactors and storage vessels (95 total relief systems). Some of the safety valve discharges were routed to a common header, resulting in worst case multiple relief scenarios (fire case) with relief system capacities dependent on collection header backpressure calculations. The Aspen Plus® steady state pressure relief evaluator (an embedded function based on API 520/521 and NFPA standard calculation methods) was used to determine existing relief system capacities by indexing all solvents to acetone.

In Order of Descending Orifice Sizing Factors

	Abs T @ 100 psig *R*	MW	λ @ T *BTU/lb*	*k* @ T	C_k	*Z* @T,P	Factor $(1/(\lambda*C_k)*\text{Sqrt}(T*Z/MW)$	Orifice Size Indexed to DMK
BUDIOX	1102.88	162.23	92.63	1.02	318.02	0.83	8.07E-05	1.45
EEP	956.60	146.19	91.52	1.03	318.77	0.82	7.95E-05	1.42
CYCLO100	976.36	122.80	102.42	1.03	319.12	0.80	7.71E-05	1.38
NBACE	881.73	116.16	102.37	1.04	319.77	0.83	7.69E-05	1.38
PGMEACE	916.20	132.16	98.41	1.03	319.32	0.83	7.62E-05	1.37
MNAK	939.15	114.19	107.56	1.03	319.29	0.83	7.60E-05	1.36
MIBK	869.01	100.16	111.37	1.04	320.19	0.84	7.58E-05	1.36
O-XYLENE	929.28	106.17	117.45	1.04	320.16	0.85	7.26E-05	1.30
BUOX	970.55	118.18	114.41	1.03	319.23	0.84	7.19E-05	1.29
TOLUENE	856.78	92.14	124.67	1.05	321.57	0.86	7.05E-05	1.26
CYCLOHEX	956.14	98.14	134.10	1.04	320.46	0.86	6.73E-05	1.21
EGPE	941.20	104.15	134.08	1.04	319.96	0.86	6.49E-05	1.16
MEK	780.82	72.11	152.65	1.07	323.09	0.86	6.19E-05	1.11
NMP	1051.60	99.13	159.13	1.04	320.38	0.87	5.95E-05	1.07
DAA	945.90	116.16	143.90	1.04	319.59	0.85	5.73E-05	1.03
NITROC2	857.85	75.07	172.02	1.08	324.53	0.88	5.68E-05	1.02
DMK	728.90	58.08	181.40	1.10	326.55	0.87	5.58E-05	1.00
DMF	938.99	73.09	187.69	1.06	322.47	0.86	5.51E-05	0.99
PGME	848.15	90.12	162.53	1.05	321.16	0.87	5.48E-05	0.98
BLO	1042.07	86.09	196.61	1.06	321.98	0.89	5.18E-05	0.93
NBA	835.51	74.12	189.44	1.06	321.90	0.86	5.11E-05	0.92
IPA	755.19	60.10	227.33	1.08	324.17	0.87	4.48E-05	0.80
METHANOL	721.81	32.04	405.15	1.19	336.35	0.91	3.32E-05	0.60

According to API guidelines, the following possible scenarios leading to a relief condition must be considered:

- Fire
- Blocked outlet/overfill
- Cooling failure
- Control system failure
- Power failure
- Hydraulic expansion
- Chemical reaction/Reactive hazards
- Other special scenarios specific to batch processes

and evaluated with other API allowances:

- 0.3 factor used for fireproof insulation credit
- 2 hours allowed for fire response time
- 15 minutes allowed for response to all other scenarios besides fire
- Two-phase relief considered, but using tools other than Aspen Plus® (to meet the DIERS two phase relief calculation standards)
- 5000 sq. ft. circular area (~40' radius) affected by a major fire to be considered for multiple relief scenarios
- All other guidelines consistent with API-520/521

With the factors in the table above and combined with the possible relief scenarios, the existing relief system capacities (valve orifices, rupture disc areas) can be more easily evaluated once the governing case is established. In some cases, understanding operator response time to a potential relief condition was necessary to mitigate certain scenarios. In these cases, the dynamic capability of the Aspen Plus® pressure relief evaluation tool was applied to the governing cases.

In conclusion, revisions to 7 relief systems were necessary to comply with the API guidelines (some relief valve replacements and some relief valve orifice modifications). In addition, the evaluation also resulted in a recommendation to replace two jacketed reactors with leaking jackets (no insulation) as a means of re-insulating the vessels to keep the relief systems a reasonable size.