Errata: CCPS Guidelines for Pressure Relief and Effluent Handling Systems (06/12/06)

Page	Location	Correction (changes are in bold)
42	Last para, 7th line	...Lai (1996)**, Table 2.4-5 (Page 57)**...
58	1st para.	…valves should be…
64	3rd para.	…set as high as **1.1** times the vessel MAWP.
71	§2.5.8, 1st line	Refer to §5.3.**4** for…
73	4th para.	Delete: the nozzle flow model with a discharge coefficient of 0.62 (see §3.6.5.2)
74	2nd para.	Add: … options (see §3.6.5.2, page 209)
74	2nd para.	Delete: …,either $Kr = 0.1$, or…
81	1st para.	Delete the last two sentences: "There is …
81	2nd para., 3rd line	…K_R values of **full-area** rupture disk devices **in gas service** has been…
81	After 2nd para.	Insert paragraph P1
81	3rd para.	Delete: …for both nozzle … coefficient is 0.62.
81	3rd para.	Replace sentence: In the pipe flow model, current certified K_R values (ASME PTC-25, 1994) represent the device flow resistance as that of a full-area flow element with the K_R value included in the total flow resistance of the piping system
81	Last para.	Delete the paragraph
82	1st para.	Delete the paragraph
82	2nd para.	Replace paragraph with P2
109	ASME address	The American Society of Mechanical Engineers, **3 Park Avenue**, New York, NY **10016-5990**
125	3rd para., last line	...in **§3B.4.2.1**.
129	Eq. (3.3-2)	$\beta = ((\rho_{flow} - \rho_2) / (T_{flow} - T_2)) / \rho_{flow}$
129	4th para.	For a liquid, β can be evaluated from the density change over a 5 °F temperature increment divided by the flowing density (ρ_{flow}).
129	Reference	(1993) API RP 520-I, Appendix C (1997) API RP 521, para. 3.14
131	References	(1993) API RP 520-I, para. 3.3.2 (1997) API RP 521, para. 3.15.1.1 (1993) API RP 520-I, para 3.3.3 (1997) API RP 521, para. 3.15.1.2 (1993) API RP 520-I, para. D.3.2 (1997) API RP 521, para. 3.15.1.2 (1993) API RP 520-I, para. D.5.2.4 (1997) API RP 521, para. 3.15.2.2
133	Table 3.3-2	Vent Rate (SCFH* AIR) Valid at approximately One Atmosphere Pressure
134	References	(1993) API RP 520-I, Table D-2 (1997) API RP 521, Table 4 (1993) API RP 520-I, Table D-3 (1997) API RP 521, Table 5
137	Eq. (3.3-10) and line above	…are approaching zero: **(Simpson, 1995a)** $W = \dfrac{C\,q}{T\,v_g\,\boldsymbol{(dP/dT)_{sat}}}$ {$(dP / dT)_{sat}$ should be in the denominator}
139	4th para., 3rd line	(Simpson, 1995**a**)
139	6th para., 5th line	…component by **the following approximation (Simpson, 1995a)**:
147	3rd para., 4th line	...(page **129)**...
148	2nd para., 5th line	... Table **3.3-2**...
148 *	2nd para., 7th line	… Eq (**3.3-2**)
157	1st para., 3rd line	...vend**o**rs...
161	1st para., 6th line	...point is illustrated... {omit be}
166	2nd line	$\tau = \dfrac{7998}{335.5} - \left[\dfrac{160.4 \times 1076}{13.69 \times 0.3451 \times 335.5}\right]^{1/2} = 13.4$ s
166	3rd line	= 3500 lbm {not lbm / s}
178	1st line	§3B.2.2.**5** (Page 269)
178	2nd para., 2nd line	§3B.4.**2.3** (Page 284)

178	§3.6.1.5, 1st line	See **§3B.3.1.6** (Page 277)
186	Ex., bottom of page	Ell KF = 0.2**7**; total KF = **0.83**; …from COMFLOW is **66.99** psia {not 67.13}
194	Table note, 3rd line	66.82 = 129.9X + (–13.9)(1 – X) {delete extra = sign}
197	Table	Liquid Wt %: Acetone – 50, Ethanol – 30, Water – 20
198	Last para., 1st sentence	Eq. (3B.2-**14**) (page 25**8**) {not Eq. (3B.2-6) (page 255)}
199	First two lines	The first two lines are duplicated from page 198
199	Eq. (3B.2-18) and (3B.2-19)	Constant should be **0.93028** (3 places)
200	1st line of Eq. (3B.2.21)	$k = (v / P)\ [(\partial P / \partial T)_v^2\ T / C_v - (\partial P / \partial \boldsymbol{v})_T]$ {missing – and T should be v}
201	1st line	Line is a duplicate of the last line on Page 200
201 *	Eq. (3.6-8)	Delete $\boldsymbol{(1 - \beta^4)}$ in the denominator
202 *	Definition of β	DELETE
206	2nd para, 7th line	Eq. (**3.6-8)** (page **201**)
208	3.6.5.1 Heading	Delete GAS OR VAPOR
209	3.6.5.1	Add following the nomenclature: See 3.6.3 for liquid flow in nozzles
209	3.6.5.2 Heading	Delete GAS OR VAPOR
209	After1st para.	Insert paragraph P3
209	2nd para.	Delete "See 2.6.4 for…
209	Last para.	Add …through (r) for the given fluid (K_{RG}, K_{RL}, K_{RGL})
210	1st para.	Replace paragraph with P4
213	Footnote	Where D is i.d. (inches) of Schedule 40 standard pipe
231	Line after Eq. (3A.3-6)	...data over a **limited** temperature range (**Reid, et al., 1987)**.
238	Eq. (3A.5-1)	$dv = \left(\frac{\partial v}{\partial T}\right)_p dT + \left(\frac{\partial v}{\partial P}\right)_T dP$ {missing + ; misplaced + }
239	Eq. (3A.5-6)	$-\frac{dP}{dT} = \frac{(1 / \rho)\ (\partial \rho / \partial T)_P + 3\alpha}{(D\ C_1 / e\ E) + (1 / \rho)\ (\partial \rho\ /\ \partial P)_T}$ {ρ in place of P in partial derivative}
239 *	Middle of page	The modulus of elasticity is 3×10^7 {not 3×10^6}
239	Table 3A.5-1	dP/dT, psi / °C (acetic acid...water): **155, 155, 155, 166, 197, 164, 47**
246	Eq. (3A.6-6)	ϕ should be in the numerator, not the denominator
256	Eq. (3B.2-8)	$\frac{P_{in}^0}{P_{in}} = \left[\frac{\boldsymbol{v}_{\mathbf{in}}\ G^2\ (k-1)}{2\ g_c\ k\ P_{in}} + 1\right]^{k/(k-1)}$ {$\boldsymbol{v}_{\mathbf{in}}$ misplaced; no = sign}
258	Reference	(1993) API RP 520-I, para. 4.3.3.1 (2000) API RP 520-I, para. 3.6.3
259	Eq. (3B.2-21)	Last term should be $(dP\ /\ dT)_T$
260	References	(1993) API RP 520-I, para. 4.3.3.1 (2000) API RP 520-I, para. 3.6.3 (1993) API RP 520-I, para. 4.3.3.1 (2000) API RP 520-I, para. 3.6.2
262	Eq. (3B.2-29)	$-dP = \frac{1}{g_c} G^2\ dv + \left(\frac{dP}{dL}\right)_{\mathbf{fr}} dL + \frac{g}{g_c}\frac{1}{v}\ dZ$ {fr subscript; also in $\left(\frac{dP}{dL}\right)_{\mathbf{fr}}$ definition}
265	In place of text starting with "The Churchill values… and ending with Eq. (3B.2-36b)	The friction factor is calculated from the following BASIC-like procedure: $f_1 = 64 / N_{Re}$ If N_{Re} < 1,000 Then $f = f_1 / 4$ (laminar f) (3B.2-36) Else ($N_{Re} \geq 1{,}000$) $\varphi = -2 \log_{10} [(\varepsilon / D) / 3.7 + (7 / N_{Re})^{0.9}]$ $f_3 = \{-2 \log_{10} [(\varepsilon / D) / 3.7 + 2.51\ \varphi / N_{Re}]\}^{-2}$

		If N_{Re} < 10,000 Then $f_2 = (Re / 13{,}269)^2$ $f = [f_1^{12} + (f_2^{-8} + f_3^{-8})^{-3/2}]^{1/12} / 4$ (transitional f) (3B.2-36a) Else ($N_{Re} \geq 10{,}000$) $f = f_3 / 4$ (turbulent f) (3B.2-36b) End If (end of inner "If…Then…Else" statement) End If (end of outer "If…Then…Else" statement)
270	1st sentence	Add: For incompressible or two-phase flow, equation (3B.2-40) can be solved…
270	1st para.	Delete: …and close to unity for gas flow. Add: Do not follow the common practice of using $\omega = 1$ for gas flow.
270	1st para.	Delete the words: "For any fluid," Add: "Using physical property information, the value of …"
270	After 1st para.	Insert paragraph P5
270	2nd para., 1st line	If the flow is choked at $\boldsymbol{P_1}$…
270	3rd para., 1st line	Some designers follow the practice of… {delete conservative}
270	Eq. (3B.2-42)	$\boldsymbol{G_c^2 = (-\partial P / \partial v)_s}$ {inverted P and v; subscript error; sq. rt. (t.)}
273	3rd para., 1st line	...program at each... {omit 2nd the}
273	Table 3B.3-1, Model C	$v / v_A - 1 = a\ \mathbf{[}(P_A / P)^b - 1]$ {missing bracket}
274	3rd line	✧ TPHEM then sets $b_1 = 1$, $c_0 = 0$, and computes a_0 and b_0 {$c_1 \neq 0$; b_0, not bo}
274	4th - 6th line (replace)	**For frozen flow use the two-point Model E with $X_B = X_A$ (see §3B.4.3.2.2).**
274	1st para., 3rd line	§3B.4.**2.3**
274	§3B.3.1.1, 3rd line	(somewhat more rigorous for gas flow **through pipes**).
274	3rd to last line	Table **3B.3-1** {not Table 3B.23-1}
274	2nd to last line	$X = \mathbf{0}$
275	Table 3B.3-2	Temperature $T_0\ (P_0 / P)^{\boldsymbol{(k-1)/k}}$ T_0 {Error in power}
275	Table 3B.3-2	v_g $v_0\ (P / P_0)^{-1/k}$ $v_0\ (P / P_0)^{-1}$ {Error in power}
279	Last para., reference	Eq. (3B.2-**29**)
282	Eq. (3B.4-7)	$G_t^2 = \frac{2\, g_c\, P_0}{v_t^2}\left\{(1 - X)\, v_f \left(1 - \frac{P_t}{P_0}\right) + \frac{X\, v_{g0}\, k^*}{k^* - 1}\left[1 - \left(\frac{P_t}{P_0}\right)^{(k^*-1)/k^*}\right]\right\}$ {missing brackets and subscript 0 in v_{g0}; pressure term}
282	Below Eq. (3B.4-7)	$v_t = (1 - X)\, v_f + X\, v_g\, (P_t / P_0)^{\boldsymbol{-1/k^*}}$ {last part should be raised to the power}
283	1st para.	Eq. (3B.2-18) should be Eq. (3B.2-44)
283	Eq. (3B.4-8)	$g_c\, G_c^{-2} = \frac{X\, v_g}{k\, P_c} + \frac{N_{ne}\, (v_{fg} / H_{fg})^2\, (C_f\, T - X\, H_g)}{J}$ {missing – in –2 power}
283	2nd para., 2nd to last line	ft ·lb$_m$ / **BTU**… {not ft ·lb$_m$ / (lb$_f$ ·s^2)}
292	Table 3B.4-3	Replace ITPS with **IPTS** (two places)
292	3rd line	(Leung, **1995**)
292	Table 3B.4-3	For all options, see: "TPHEM – Supplement for Advanced Users" (attached)
294	--	Page is not numbered
294	Table 3B.4-5	For all options, see: "TPHEM – Supplement for Advanced Users" (attached)
294	Table 3B.4-5	Code IC, **3 = Advanced User**
295	Table 3b.4-6	Table 3**B**.4-6
295	Table 3B.4-6	For all options, see: "TPHEM – Supplement for Advanced Users" (attached)
296	Table 3B.4-7	**Enthalpy** {misspelled}

296 *	Table 3B.4-7	lbm / ft^3 {heading}
296	Table 3B.4-7	Replace Data Set with **State**
368	Fig. 5.4-3, 2nd right box	Read value of y from Figure **5.4-4** {wrong number}
369	2nd line	...(**5.4.10**) through (**5.4.12**)...
370	Eqs. (5.4.4) and (5.4.5); These equations are preferable.	$D = \sqrt{\dfrac{4\,Q_g\,(1-y)}{\pi\,C\,u_t\,(1-x)}}$ (5.5.4) $C = L / D$ (a user-specified length-to-diameter ratio) (5.5.5)
371	3rd para., 1st line	Figure **5.4-4**
386	3rd line from bottom	...sum of **partial** pressures...
387	P_l, P_q	**Should be partial pressures, except when the condensable and quench liquids are immiscible**
388	• *Gas holdup*	Replace bullet text with: • *Gas holdup* is the gas trapped in the bubbling liquid. • *Entrainment*. An allowance for additional gas volume (freeboard) is also needed to minimize entrainment losses.
393	Last symbol	$\boldsymbol{H_{q0}}$ = enthalpy of quench liquid at initial temperature
396 397	P_l, P_q	**Should be partial pressures, except when the condensable and quench liquids are immiscible**
397	3rd line	Equation (**5.6.5**)...
403	2nd para., 4th line	...**partial** pressure...
403	P_{v1}, P_{v2}	= **partial** pressure of pool... {not vapor pressure}
434	Eq. (5.9.3)	$M_2 = 1.702 \times 10^{-5} \left(\dfrac{W}{P\,D^2}\right)\left(\dfrac{Z\,T}{k\,M_w}\right)^{\mathbf{1/2}}$ {missing ½ power}
461	Complete page	May be a duplicate of Pg. 460; see correct page (attached)
469	2nd para.	…each component in **the** vapor leaving…
487	Reference	API RP 520-I, **7th Ed. (Jan 2000)**
488	6th entry	ASME BPVC. Boiler and Pressure Vessel Code, Section VIII, Division 1, Pressure Vessels, **2001**, ASME, New York, NY
490	Reference	Bluhm, W. C. (**1962**)
492	Bottom of page	Some may have poor print quality; see correct page (attached)
506	Reference	Add: Schmidt, J. and Giesbrecht, H., “Design of Cyclone Separators for Emergency Relief Systems”, PSP, 20(1), 6-16 (March 2001)
508 *	Reference	Straitz (1987a) should be Straitz, J. F., (1977). “Make the Flare Protect the Environment”, Hydrocarbon Processing, (56), 131-135.

* New Addition Since 12/28/04

1. Paragraph P1 (Page 81, Insert after 2nd Paragraph)

The calculation method of ASME PTC-25 (1994) uses the area of the nominal pipe size of the device as the minimum net flow area basis for determining the K_R value from the flow test data (air or gas flow). The method was developed for use with essentially full-area devices (no structural elements remaining in the flow path after complete burst of the disk). Current practice is to apply this calculation method to reduced-area devices as well. When so applied to devices with a ratio of device flow area to pipe area ("area ratio") less than about 0.8, the apparent K_R value increases with test pressure in the lower pressure ranges, becoming constant at higher pressures. This constant value is appropriate for current K_R certifications. Relief system designs based on such K_R values must use the same device area basis as specified in the certification tests (area of nominal pipe size of the device per current practice).

The apparent pressure dependency of K_R for reduced-area devices is not observed if the calculation method is based on the specified minimum net flow area of the fully-blown device rather than on the nominal pipe size. On this basis, conditions of maximum flow in the device area (sonic, critical, "choked" flow) are recognized and treated rigorously. See Huff, J. E., "Restrictive Rupture Disc Devices: A Calculation Method for Certification and Design" (Topical Conference Proceedings of the 2001 Process Plant Safety Symposium, AIChE Spring National Meeting, pp. 578-584, April 2001) for an early version of such a calculation method. Since the present PTC-25 calculation method does not recognize flow-limiting critical flow, calculated flows can be several percent on the high side for restrictive devices under conditions of high operating pressure and/or short lengths of associated piping. However, the specified 0.9 reduction for calculated flows assures a conservative result for selecting an adequate relief device size. The present method is inherently conservative for subcritical flow.

The certification and design approach based on actual flow area may well be adopted as the supporting technology matures and PTC-25 evolves. Relief system design with such K_R values must use the specified minimum net flow area when calculating the pressure loss in the device. For devices with area ratios less than about 0.65, vena contracta effects appear to reduce the effective minimum flow area to some extent in subcritical flow. The designer must have information to account for this effect if significant for a given device.

2. Paragraph P2 (Page 82, Replace 2nd Paragraph)

In the code certification procedure, the K_R values are determined from flow tests with air or gas. The choice of fluid used for burst tests depends on the intended service (ASME BPVC 2001, U-131(l)) and the K_R values are designated:

- K_{RG}: burst with air or gas
- K_{RL}: burst with water
- K_{RGL}: At least one of the included specimens burst with water
-

Note that some styles of rupture disk devices are not recommended for liquid service. Consult manufacturers for a suitable style.

The Code design methods are formulated to give conservative results (under-estimate of flow to give ample relief size). While appropriate for relief sizing purposes, this rated flow capacity may well be under-conservative for purposes of effluent handling system sizing, particularly when reduced-area devices are used. See §3.6.5.2 for considerations in relating the best estimate flow to the rated relieving capacity.

3. Paragraph P3 (Page 209, Insert After 1st Paragraph)

Use Equation (3B.2-9) if the flow is critical (choked) at the minimum flow area. If the flow is not choked, use Equation 3B.2-23, p. 260 (with K added as in Equation (3B.3-9) above), where

* $r = P_1 / P_o$
  P_o = stagnation pressure at device inlet flange (see equation (3B.2-8), page 256, or use the pressure in the relieving vessel)
  P_1 = pressure at minimum flow area
* $\rho_o = (MW\ P_o) / (Z\ R\ T)$
  Z = compressibility as determined in 3B.2.1.3, page 258 (Z = 1 for ideal gas)
  R = gas law constant
* MW = molecular weight

Do not use the following test for critical flow (conventional practice for pressure relief valves):

$$P_2 / P_o < [2 / (k + 1)]^{k / (k-1)}$$

where P_2 = back pressure in piping at device. This criterion presumes that there are no losses in the device (ideal nozzle) and that $P_1 = P_2$. This is true only if the discharge is from an ideal nozzle to atmosphere (or to a large reservoir). Instead, calculate P_1 from the known value of P_2 using the pressure-recovery technology of 3B2.2.5, p. 269. See: Huff, J. E., "Flow Models for Reduced-Area Rupture Disc Devices: Accounting for Pressure Recovery in Tests for Choking" presented at the DIERS Users Group Meeting, Albuquerque, NM, October 15, 2001

* Revision Since 12/28/04

4. Paragraph P4 (Page 210, Replace 1st Paragraph)

The rated relieving capacity so calculated is intended to give a conservative (low) estimate of the actual capacity (in order to assure adequate relief sizing). Some upward adjustment is required to obtain the best estimate flow for effluent handling system design. This adjustment depends on the ratio of the actual flow area of the device to that of the piping ("area ratio"). Current PTC-25 practice is to determine certified K_R values as if the area ratio were unity. Flows calculated from such values are suitable for determining best estimate flow for actual area ratios of about 0.8 or higher. However, the 0.9 reduction in the rated relieving capacity must be removed.

The appropriate upward adjustment for area ratios less than 0.8 depends on both the area ratio and the length of the associated piping. Consider the case of a relief system with a vacuum support, area ratio of 0.4, which remains in the flow path after complete device rupture. Calculations based on the conditions in the actual flow area of the device show that gas flow can be sonic in typical relief system configurations, particularly at the higher relieving pressures and/or shorter tail pipe lengths. The design method as used with current K_R values does not account for this flow limitation, and thus yields estimates as much as 10% higher than the sonic-flow result for very short tail piping. For systems with longer tailpipes, the present method yields estimates on the low side (almost 10% low at about 150 diameters of tail pipe for low relieving pressures). Estimates remain conservative for long tail pipes (about 5% low at 800 diameters). Thus, merely removing the mandatory 0.9 reduction from the rated relieving capacity does not yield a uniformly good best-estimate flow. Obtain the services of an experienced consultant if 10% uncertainty in the best estimate flow, plus or minus, is not acceptable for effluent handling design.

5. Paragraph P5 (Page 270, Insert After 1st Paragraph)

For gas flow, use the following equations to calculate the conditions at the exit of the smaller duct from the conditions in the larger duct (Hall and Orme, 1955). The values in the larger duct are determined by calculating back up from a downstream point of known conditions. Using subscript 1 for the smaller duct and 2 for the larger:

$$m_2 = \{(k + 1)\, M_2^2 / [(k - 1)\, M_2^2 + 2]\}^{1/2}$$

$$m_1 = [- y + (y^2 - 4\, x\, z)^{1/2}] / [2x] \qquad \text{(I)}$$

where $x = m_2\, [(k - 1) / A_r - 2k] / [k + 1]$

$y = m_2^2 + 1$

$z = - m_2 / A_r$

$$M_1 = \{2m_1^2 / [(k + 1) - (k - 1)\, m_1^2]\}^{1/2} \qquad \text{(II)}$$

If this recovery calculation is attempted when the flow from the smaller duct is sonic (choked), then either the argument of the square root in Equation (I) will be negative or M_1 from Equation (II) will be greater than one. The expansion calculation is thus not needed since the flow is controlled by conditions in the smaller pipe. Set $M_1 = 1$.

If $M_1 < 1$:

$v_1 = v_2\, A_r\, m_1 / m_2$

$T_1 = T^o / [1 + (k - 1)\, M_1^2 / 2]$

If $M_1 = 1$:

* $T_1 = T^o / [1 + (k - 1) / 2] = T^o\, [2 / (k + 1)]$

$v_1 = (g_c\, k\, R\, T_1\, Z / mw)^{1/2} / G_1$

In either case:

* $P_1 = (Z\, R\, T_1)/ (MW\, v_1)$

where:

k = isentropic expansion coefficient
* M = Mach number = $(G\, v) / c$
* c = sonic velocity = $(g_c\, k\, R\, T\, Z / MW)^{1/2}$, (ft / sec)
* A_r = duct flow area ratio = A_1 / A_2
m = modified Mach number
T = temperature, ^{o}R
T^o = stagnation temperature, ^{o}R (constant throughout an adiabatic system; use upstream vessel temperature)
* R = gas law constant = 1544 $(ft^3 \cdot lb_f / ft^2) / (lbmol \cdot {}^oR)$
Z = compressibility
* MW = molecular weight, $(lb_m / lbmole)$
* G_1 = mass flux, $(lb_m / (ft^2\, sec))$
* v_1 = specific volume, (ft^3 / lb_m)
* g_c = gravity constant, $(lb_m\, ft) / (lb_f\, sec^2)$
other parameters as defined above

* Revision Since 12/28/04

TPHEM – SUPPLEMENT FOR ADVANCED USERS

Several latent feature are incorporated into TPHEM, including options to handle Non-Equilibrium and Slip (NES) models for nozzles, a viscous correction option, and additional IPTS options. All IPTS options in Ref. 2 are implemented in TPHEM. They are summarized in the following table.

IPTS	DATA STATES	MODEL
-5	3	D[2]
-4	3	B[2]
-3	3	C[2]
-2	2	A[2]
-1	1	Omega type[2]
1	1	Omega type[1]
2	2	E[2]
3	3	F[2]

REFERENCES

1. Simpson, L. L., Chem. Eng., pp 98-102, Aug. (1991).
2. Simpson, L. L., Navigating the Two-Phase Maze, "Proc. of International Symposium on Runaway Reactions and Pressure Relief Design," G. A. Melhem and H. G. Fisher eds., AIChE/DIERS, New York (1995).

FILE INPUT FOR TPHEM.EXE

LINE 1	
All cases	CASE DESCRIPTION TEXT
LINE 2	
All cases	IU, IC, IPTS, IV [a]
IF IC = 3 [b]	INES
IF INES = 1	KNE
ELSE IF INES = 2	S
ELSE IF INES = 5	KS
ELSE IF INES = 11	KNE, S
IF IV = 4	B [c]
LINE 3	
IF IC = 1, 3	
IF IV = -1 [d]	P0, P3, N, DH
ELSE IF IV = 1	P0, P3, N
ELSE IF IV[e] = ±2, 4	P0, P3, AN, K
ELSE IF IV = ±3 [f]	P0, P3, L, D, KF, MF, DH, ES
ELSE IF IC = 2	
IF IV = ±1	G, P3, N
ELSE IF IV = ±2, 4	W, P3, AN, K
ELSE IF IV = ±3	W, P3, L, D, KF, MF, DH, ES
ELSE IF IC = 4 [g]	
IF IV = -1	P0, G, N, DH
ELSE IF IV = 1	P0, G, N
ELSE IF IV = ±3	P0, W, L, D, KF, MF, DH, ES
ELSE IF IC = 5 [h]	
IF IV = -1	P1, G, N, DH
ELSE IF IV = 1	P1, G, N
ELSE IF IV = ±3	P1, W, L, D, KF, MF, DH, ES
LINE 4	
IF IV = ±1, -2, -3	PA, XA, RGA, RLA
ELSE IF IV = 2, 3, 4	PA, XA, RGA, RLA, ZGA, ZLA
LINE 5	
IF IPTS = ±1	TA, CPLA, HFGA
ELSE IF IPTS = ±2, ±3, -4, -5	
IF IV = ±1, -2, -3	PB, XB, RGB, RLB
ELSE IF IV = 2, 3, 4	PB, XB, RGB, RLB, ZGB, ZLB
LINE 6	
IF IPTS = ±3, -4, -5	
IF IV = ±1, -2, -3	PC, XC, RGC, RLC
ELSE IF IV = 2, 3, 4	PC, XC, RGC, RLC, ZGC, ZLC
ELSE	BLANK LINE

(a) Use commas or spaces between adjacent data entries.

(b) IPTS must be greater than zero for INES to be active. For INES =

1. Homogeneous Non-Equilibrium model described in Reference 1. The weight fraction vapor XNE = XA + KNE (X^2 - XA^2), where KNE = 1 will yield results similar to those from the Henry-Fauske model.
2. Input fixed slip ratio. S = 1.5 works well for safety valves with two-phase entry (not liquid).
3. Slip ratio S = $(RL / RG)^{1/3}$ (Moody model), where RL / RG is the local density ratio in the nozzle.
4. Slip ratio S = $(RL / RG)^{1/4}$ (Chisholm slip), where RL / RG is the local density ratio in the nozzle.
5. Slip ratio S = $(1 - X + X * RL / RG)^{KS}$. For nozzles with two phase entry, KS is expected to be close to 0.25.

11. Combination of INES = 1 and INES = 2; a fixed-slip non-equilibrium model.

(c) B is ID of nozzle divided by ID of upstream pipe.

(d) TPHEM uses the simple algorithm described in Reference 1.

(e) TPHEM uses API viscous correction if IV = ±2, Darby-Molavi when IV = 4.

(f) Use this combination only when IC = 1.

(g) Use this option to calculate irreversible pressure losses from a reservoir into piping.

(h) Use this option to calculate pressure drop in piping, given the upstream pressure.