20 variations: $\Delta T_1 = 250^\circ F$ (140$^\circ$C) heating
10 variations: $\Delta T_2 = 150^\circ F$ (80$^\circ$C) cooling
100 variations: $\Delta T_3 = 100^\circ F$ (56$^\circ$C) cooling

Lump the ranges of variation so as to produce the greatest effects as follows:

10 cycles $\Delta T_{f1} = 250 + 150 = 400^\circ F$
(140 + 80 = 220$^\circ$C)
10 cycles $\Delta T_{f2} = 250 + 100 = 350^\circ F$
(140 + 56 = 196$^\circ$C)
90 cycles $\Delta T_{f3} = 100^\circ F(56^\circ C)$

(c) Pressure fluctuations not excluded by NB-3552 are to be included in the cyclic load calculations. The full range of pressure fluctuation from the normal condition to the condition under consideration shall be represented by $\Delta p_i$ in NB-3554.

**NB-3554 Cyclic Stress Calculations**

A valve conforming to NB-3512.1 shall be qualified by the procedure of (a) through (d) below.

(a) The following criterion shall be met by the greatest temperature range:

$$Q_p \left[ \frac{\Delta p_{f\text{max}}}{B_2} \right] + C_6 C_2 C_4 \Delta T_{f\text{max}} < 3S_m$$

where $\Delta T_{f\text{max}}$ is the largest lumped temperature range obtained using the methods of NB-3553(b), and $\Delta p_{f\text{max}}$ is the largest range of pressure fluctuation associated with $\Delta T_{f\text{max}}$.

(b) Calculate:

$$S_{n\text{max}} = Q_p \left[ \frac{\Delta p_{f\text{max}}}{B_2} \right] + C_6 C_2 C_4 \Delta T_{f\text{max}}$$

Provided that $S_{n\text{max}} \leq 3S_m$, calculate the fatigue stresses for each cyclic loading condition as follows:

$$S_i = \frac{4}{3} Q_p \left( \frac{\Delta p_{f}}{B_2} \right) + C_6 (C_3 C_4 + C_5) \Delta T_{f}$$

Determine the allowable number of cycles $N_i$ for each loading condition by entering Section III Appendices, Mandatory Appendix I, Figures I-9.1 and I-9.2 with $S_i/2$, and determine the fatigue usage by NB-3553(a).

(c) If $S_{n\text{max}}$ is greater than $3S_m$ but less than $3mS_m$, the value of $S_i/2$ to be used for entering the design fatigue curve is to be found by multiplying $S_i$ by $K_n$ where:

$$K_n = 1.0 + \frac{(1 - n)}{(n(m - 1))} \left( \frac{S_i}{3S_m} - 1 \right)$$

and where the values of the material parameters $m$ and $n$ are as given in Section III Appendices, Mandatory Appendix XIII, Table XII-3450-1.

(d) If $S_{n\text{max}}$ is greater than $3mS_m$, use $K_n = 1/n$.

**NB-3560 DESIGN REPORTS**

**NB-3561 General Requirements**

The certified Design Reports listed in this paragraph meet the requirements of NCA-3211.40 for the Design Report.

**NB-3562 Design Report for Valves Larger Than NPS 4 (DN 100)**

A Design Report shall be prepared in sufficient detail to show that the valve satisfies the requirements of NB-3512. For a valve designed in accordance with NB-3512.1, the Design Report shall show that the applicable requirements of NB-3530, NB-3541 through NB-3546.2, and NB-3550 have been met. It is not necessary to write a special Design Report based on specified Design Pressure and Design Temperature when they are within the pressure-temperature rating and when supplemental information or calculations are also provided, as necessary, to complete the report for a specific application, such as the thermal cyclic duty evaluation of NB-3550. A report submitted demonstrating a design for loadings more severe than the specified loadings is also acceptable.

**NB-3563 Design Report Requirements for NPS 4 and Smaller ($\leq$DN 100) Valves**

For valves whose inlet piping connection is nominally NPS 4 (DN 100) or smaller, the Design Report shall include details to show that the requirements of NB-3513 have been met.

**NB-3590 PRESSURE RELIEF VALVE DESIGN**

**NB-3591 Acceptability**

**NB-3591.1 General.** The rules of this subarticle constitute the requirements for the design acceptability of direct spring-loaded pressure relief valves. The design rules for pilot-operated and power-actuated pressure relief valves are covered by NB-3510 through NB-3563. The requirements of Article NB-7000 relative to set pressure, lift, blowdown, and closure shall be met.

**NB-3591.2 Applicable Items.** The rules of this subarticale cover the pressure-retaining integrity of the valve inlet and outlet connections, nozzle, disk, body structure, bonnet (yoke), and body-to-bonnet (yoke) bolting. The rules of this subarticale also cover other items such as the spring, spindle (stem), spring washers, and set pressure-adjusting screw. The rules of this subarticale do not apply to guides, control ring, bearings, set screws, and other non-pressure-retaining items. Figures NB-3591.2-1 and NB-3591.2-2 are illustrations of typical direct spring-loaded pressure relief valves.