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Seismic Qualification of Auxiliary Feed Water Control Valve

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1. Introduction

Although domestic nuclear power industry has almost accomplished technical independence, Auxiliary Feed Water Control Valve (AFWCV) is still depending on import. In order to jump to advanced nation in nuclear power industry, it is very important to achieve technical independence in designing and manufacturing AFWCV. At last, AFWCV is self-manufactured using the domestic technology under the financial support of the government. Therefore, the seismic qualification is carried out to verify the safety and operability of AFWCV against the earthquake in this study.

2. Seismic Qualification Condition

In order to carry out the seismic qualification of AFWCV, numerical analysis method is selected among the seismic qualification methods in IEEE 344 because AFWCV is passive valve which is not necessary to verify the operability under earthquake.

AFWCV is classified into ASME Code Class 2 and self-weight, design pressure ($214.28kg/cm^2$), and earthquake loads such as OBE (Operating Basis Earthquake) and SSE (Safe Shutdown Earthquake) are considered for seismic qualification of AFWCV. Acceleration level required in the technical specification of AFWCV, is shown in Table 1.

The followings have to be proved for the seismic qualification of AFWCV : First, the 1st natural frequency of AFWCV has to be over 33Hz. Second, member stress of AFWCV under seismic qualification loads has not to excess allowable stress prescribed in ASME Code NC 3592. Finally, displacement between each part due to the seismic qualification loads, has to be within allowable one to keep its proper operation under the earthquake as shown in Table 2.

Table 1. Maximum acceleration (unit : g)

	N-S direction	E-W direction	Vertical direction
OBE	4.0	4.0	4.0
SSE	5.0	5.0	5.0

3. Numerical Analysis

3.1 Analytical model

Table 2. Allowable displacement

Location	Allowable displacement
Between stem and bonnet	0.2~0.3mm
Between plug and plug guide(disk stack)	0.2~0.3mm

ABAQUS 6.5-1 is used as a numerical analysis program to carry out the seismic qualification of AFWCV and 8 parts such as Body, Bonnet, Plug guide, Disk stack, Seat ring, Stem, Plug, and Yoke which compose AFWCV, are modeled and 4-node solid element is adopted for numerical analysis model.

Figure 1 shows the finite element model of AFWCV and Table 3 indicates the material properties of each part.

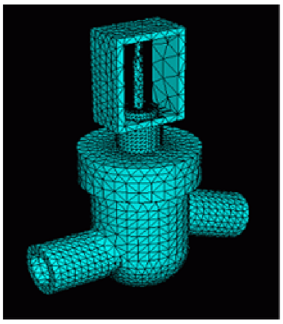


Figure 1. Numerical analysis model of AFWCV

Table 3. Material properties

Part	Material	Elastic modulus (kgf/cm^2)	Unit weight ($10^{-7}kgf/cm^3$)	Allowable stress (kgf/cm^2)
Body Bonnet	CF8M	19,400,000	8.0	1,212.5
Plug guide Disk stack	SUS420J2	21,500,000	7.69	1,350
Seat ring / Stem / Plug	SUS316	19,300,000	7.96	1,300
Yoke	A217	18,900,000	8.01	1,212.5

3.2 Modal analysis

Modal analysis is carried out to verify whether the 1st natural frequency is over 33Hz or not. As a result, the 1st natural frequency of AFWCV is 142.93Hz and AFWCV satisfies the first seismic qualification requirement. Table 4 indicates the main natural frequency of AFWCV and the 1st mode shape is as shown in Figure 2.

Table 4. Main natural frequency of AFWCV

Modal No.	Natural frequency (Hz)
1	142.93
2	152.00
3	478.94

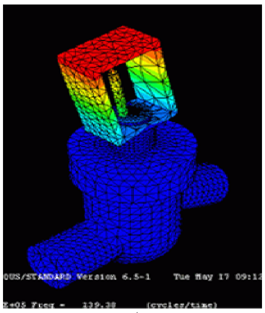


Figure 2. The 1st mode shape

3.3 Numerical Analysis

Numerical analysis is performed using various loads as stated above for seismic qualification of AFWCV. And then, the analytical results such as stress and displacement are compared with allowable ones shown in Table 2 and 3. For simplicity of numerical analysis, member stress due to loads of service limit level D are compared with allowable stress of service limit level B conservatively.

Table 5 shows the comparative results between calculated member stress and allowable stress prescribed in ASME Code. Also, Table 6 shows the comparative results about displacement. Therefore, AFWCV satisfies the other seismic qualification requirements and it is verified that AFWCV is able to operate normally under the earthquake.

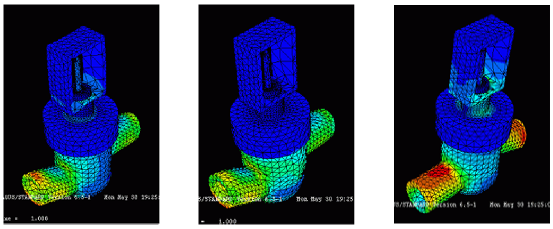
Table 5. Comparison between calculated and allowable stress

Part	Member Stress (kgf/cm^2)	Allowable stress (kgf/cm^2)	Remark
Body	1,959	2,000	OK
Bonnet	90	2,000	OK
Plug guide / Disk stack / Seat ring	857	2,145	OK
Stem / Plug	518	2,145	OK
Yoke	25	2,000	OK

Table 6. Comparison between calculated and allowable displacement

Location	Displacement	Allowable Displacement	Remark
Between Stem and Bonnet	0.07mm	0.2~0.3mm	OK
Between Plug and Plug guide or Disk stack	0.07mm	0.2~0.3mm	OK

Representative results from each load are shown in Figure 3.



(a) Self weight (b) Design pressure (c) Acceleration

Figure 3. Stress Contour of AFWCV

4. Conclusion

In this study, the safety and operability of AFWCV manufactured in Korea to produce home-production valve, are assessed against the earthquake through the seismic qualification.

Seismic qualification of AFWCV is carried out using the numerical analysis method and as a result, the 1st natural frequency, stress and displacement satisfy the allowable conditions. Therefore, it is confirmed that AFWCV can operate normally under the earthquake.

REFERENCES

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