◀講　座▶

空氣 調和 熱負荷計算

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공기조화 열부하 계산방법으로는

① 概算負荷推定(略算) 面積當 냉동기 보일러의 크기 推定

② 장치설계를 위한 負荷計算 各 室別 負荷계산 用紙에 의거 最大부하계산

③ 年間運轉費 推定을 위한 負荷計算의 종류가 있다.

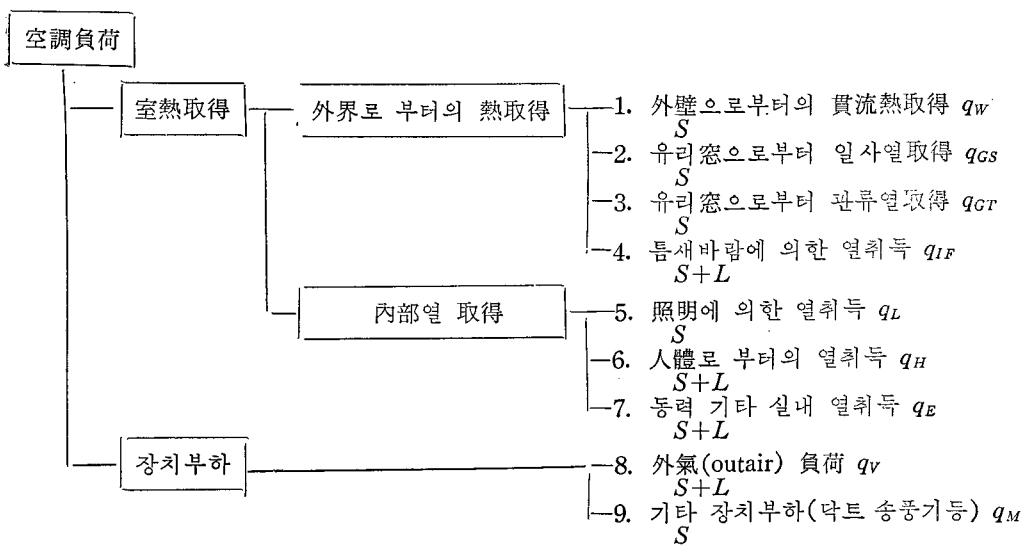
현재 부하계산이라면 주고 2번을 칭한다. 이를 위한 설계 Data와 方法이 각종 문헌에 실려있다. 代表的인 것을 들면 다음 문헌들이 있다.

○ 井上宇市 空氣調和 Handbook(번역판있음)
○ Carrier Handbook of A. C. System Design
○ 건축설계자료집성 6권
○ 日本 空氣調和 衛生工學會 編 便覽 第2권
○ Ashrae Handbook Fun lamentals 1972 & 1977 (사진복사판있음)

이들 方法은 어느것이나 周期定常傳熱(Periodic steady heat transmission thru the wall) 계산법에 근거한 유효온도차 ETD(Equivalent Temperature Differential)의 表를 미리 계산하여 보여주고 있다. 細部에 있어서는 약간식의 차이가 있다.

표 1에 냉방부하 계산항목과 항목별 계산식을 보여준다. 냉방부하 계산이 난방에 비하여 어렵고 복잡한 것은 주로 日射(Solar Radiation)의 영향이 커서 건물 外壁, 지붕과 유리창을 통한 열取得(Heat Gain)의 계산이 어렵기 때문이다.

이중 가장 어려운부분이 계산하고자 하는 벽체의 ETD 값을 表에서 찾아서 결정하는 일이다.



S: 현열취득(Sensible Heat Gain)
L: 잠열취득(Latent Heat Gain)

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各項目을 계산식은 아래와 같다.

1. q_W=열貫流率(Kor U값)×有効溫度差(ETD)×외벽면적
2. q_{GS}=일사열취득량(I_{GS})×차폐계수(k_S)×유리면적
3. q_{GT}=유리면 열관류율(K)×內外온도차($\theta_0-\theta_i$)×유리면적
4. q_{IFS}=0.24×1.2×극간풍량[m³/Hr]×內外온도차($\theta_0-\theta_i$)
   q_{IFL}=720×극간풍량[m³/Hr]×內外절대습도차(x_0-x_i)
5. q_L=床面積×面積當 watt수×1.0(형광등, 백열등은 0.86)
6. q_{HS}=床面積×在室人口密度[人/m²]×人體의 방열량
   q_{HL}
8. q_{VS}=0.24×1.2×在室人수×1인당外氣量×內外온도차($\theta_0-\theta_i$)
   q_{VL}=720×在室人수×1인당外氣量×內外절대습도차(x_0-x_i)

표 1. 서울 및 동경의 하제외기조건 비교표

시각	서울 8月 외기조건				동경 하계 외기조건			
	DB°C	WB°C	RH%	절대습도 kg/kg	DB°C	WB°C	RH%	절대습도 kg/kg
1	25.3	24.5	94		26.9	25.2		0.0196
2	25.2	24.5	94		26.6	25.2		0.0197
3	25.1	24.5	95		26.3	25.0		0.0185
4	25.0	24.5	95		26.2	24.7		0.0191
5	24.9	24.5	96		26.1	24.8		0.0192
6	24.8	24.2	97		26.4	24.8		0.0192
7	25.0	24.3	95		27.8	25.3		0.0195
8	25.9	24.5	90		29.3	25.8		0.0196
9	27.3	25.0	83		30.9	26.3		0.0197
10	28.8	25.3	76		31.9	26.7		0.0200
11	30.4	25.0	70		32.5	26.8		0.0200
12	31.8	25.8	64		32.8	27.0		0.0202
13	32.7	26.2	61		33.2	27.0		0.0201
14	33.2	26.2	59		33.2	27.0		0.0201
15	33.1	26.2	60		33.5	27.1		0.0201
16	32.1	26.2	63		32.8	26.9		0.0201
17	30.9	26.0	68		31.8	26.7		0.0201
18	29.6	26.0	73		30.7	26.4		0.0200
19	28.3	25.3	79		29.4	26.0		0.0200
20	27.3	25.2	83		28.7	25.9		0.0200
21	26.3	24.6	88		28.1	25.6		0.0198
22	25.7	24.6	92		27.8	25.7		0.0200
23	25.5	24.6	93		27.5	25.4		0.0197
24	25.4	24.6	93		27.1	25.3		0.0197
평균	27.9°C	25.1C	81%	0.0191	29.5°C	25.9°C	76%	0.0198

서울의 외기조건 :
동경의 외기조건 : T.A.C. 2.5% 하계온도조건

표 2. Air Conditioning Load Estimate

Project 197 . . . By

No.

Design condition Cooling heating

Out Side °C DB °C WB %RH °C DB %RH

Room °C DB °C WB %RH °C DB %RH

Space: Used For:

Size: × = M²× = M³

ITEM	AREA		COOLING					HEATING		
	M×M	M²	Kor S.F.	△Te or IG A.M.	△Te or IG P.M.	kcal/hr A.M.	kcal/hr P.M.	△T°C	FACTOR	kcal
ROOF										
FLOOR										
TRANSMISSION Σ										
SOLAR Σ								SUB-TOTAL		
PEOPLE	C×		kcal/hr. C					X/hr× m³= m³/hr		
POWER	kW×		860					0.31× m³/hr×		
LIGHT	W/m²		m²× 0.86					INFILTRATION		
	1.2× W/m²		m²× 0.86					SAFETY FACTOR %		
INTERNAL GAIN Σ										
INFILTRATION Σ	0.29× X/hr×		m³× °C							
SUB TOTAL										
SAFETY FACTOR			%							
TOTAL SENSIBLE HEAT										
PEOPLE	C×		kcal/hr·c							
INFILTRATION	720× X/hr×		M³× kg/kg							
SUB TOTAL										
SAFETY FACTOR										
TOTAL LATENT HEAT										
GRGRAND TOTAL COOLING & HEATING										

kcal/hr·m²

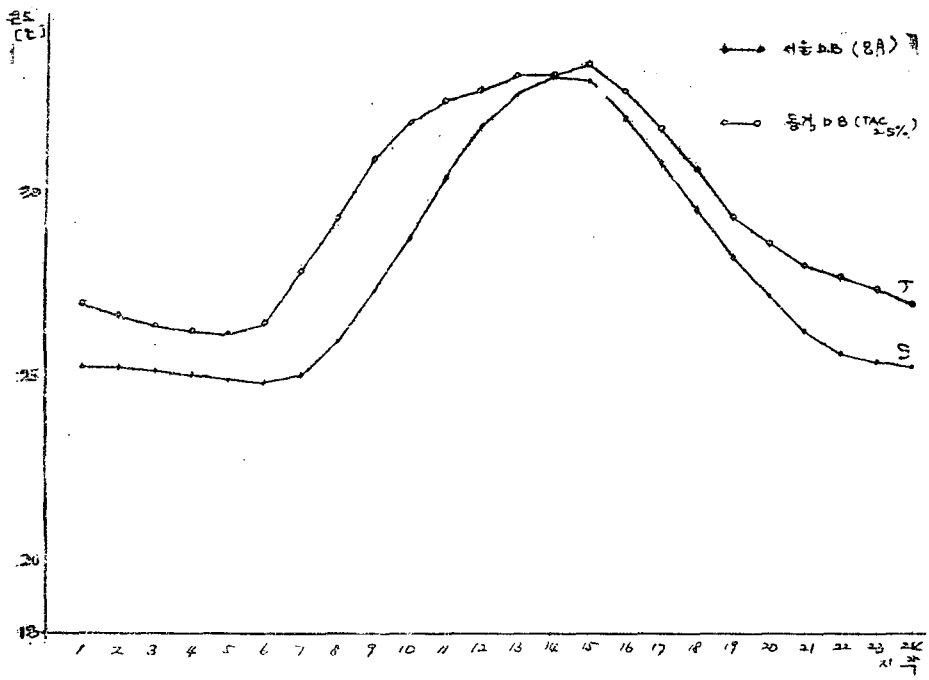

그림 1. 서울 · 동경의 夏季乾球 溫度比較

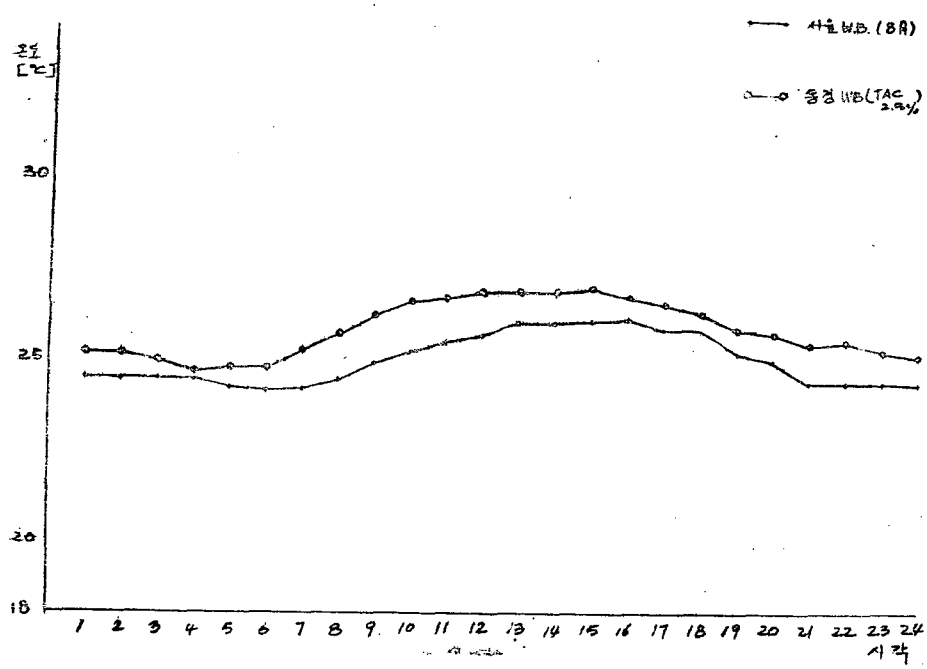

그림 2. 서울 및 동경의 夏季 濕球 溫度 比較

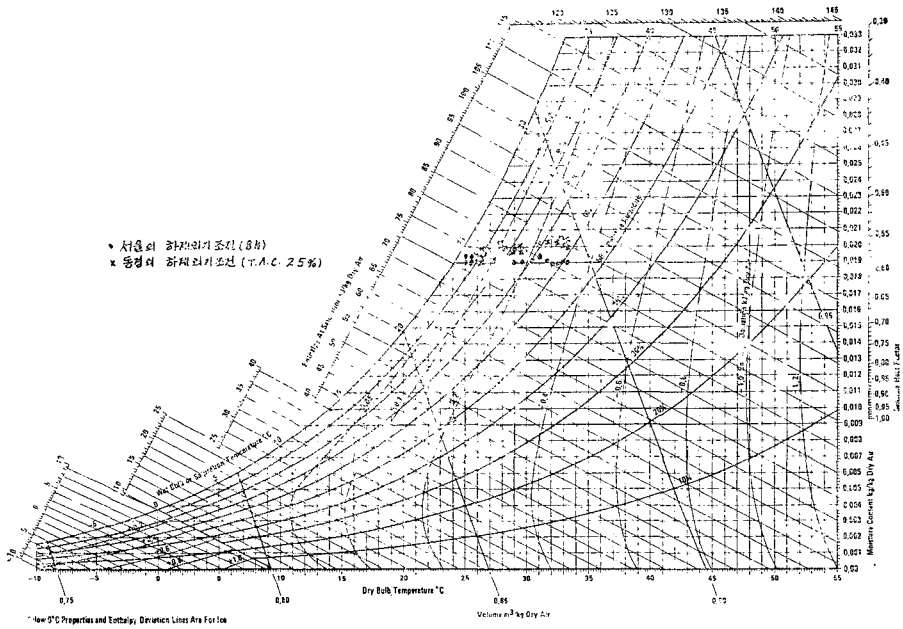

그림 3. 서울 및 동경의 하계 외기조건 비교

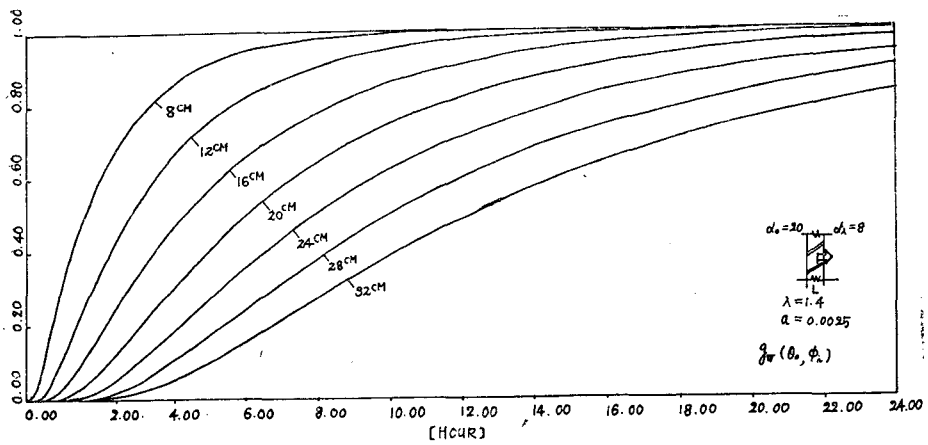

그림 4. 콘크리트 單層壁 貫流單位應答

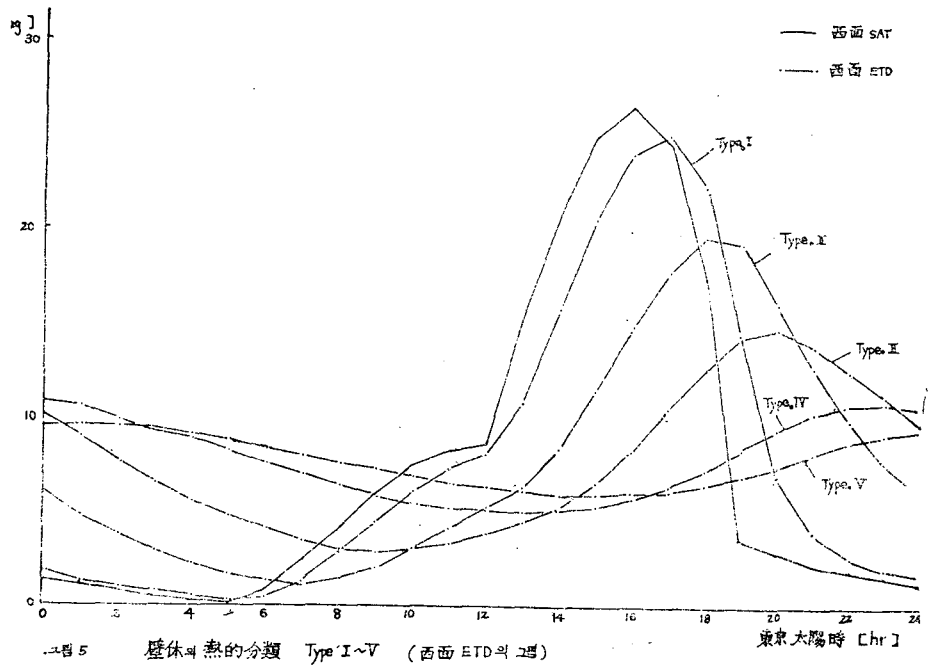

그림 5 壁体의 熱的分類 Type Ⅰ~Ⅴ (西面 ETD의 그림)

그림 5. 壁體의 熱的分類 Type Ⅰ～Ⅴ (西面 ETD의 그림)

표 3. 壁體의 傳熱應答係數(三角 hold) 콘크리트 單層壁

L=5CM	D(1)	B(1)	C(1)
0	1.0000000	1.2131300	6.5079690
1	−0.4112006	1.5532210	−3.7272340
2	0.0000032	0.0279392	0.0135562
3	0.0000000	0.0000000	0.0000000
4	0.0000000	0.0000000	0.0000000
5	0.0000000	0.0000000	0.0000000
6	0.0000000	0.0000000	0.0000000
L=10CM	D(1)	B(1)	C(1)
0	1.0000000	0.2165003	6.5567470
1	−0.7035982	0.8938980	−5.5632090
2	0.0231846	0.1855831	0.3038927
3	−0.0000005	0.0008879	−0.0005022
4	0.0000000	0.0000000	0.0000000
5	0.0000000	−0.0000003	0.0000000
6	0.0000000	0.0000000	0.0000000
L=15CM	D(1)	B(1)	C(1)
0	1.0000000	0.0289364	6.5562580
1	−0.9788435	0.3349628	−7.3492560
2	0.1551044	0.2438922	1.4342280

3	−0.0009899	0.0133956	−0.0200279
4	0.0000000	0.0000252	0.0000199
5	0.0000000	0.0000000	0.0000000
6	0.0000000	−0.0000003	0.0000000
L=20CM	D(1)	B(1)	C(1)
0	1.0000000	0.0034256	6.5563710
1	−1.2608320	0.0889339	−9.1976230
2	0.3725122	0.1689606	3.1265490
3	−0.0172220	0.0352259	−0.1891934
4	0.0000398	0.0007476	0.0011959
5	0.0000000	0.0000015	−0.0000014
6	0.0000000	0.0000002	−0.0000002
L=25CM	D(1)	B(1)	C(1)
0	1.0000000	−0.0011567	6.5555789
1	−1.5429260	0.0220690	−11.0451000
2	0.6683298	0.0746241	5.3272640
3	−0.0764282	0.0433181	−0.7131460
4	0.0013334	0.0033928	0.0177592
5	−0.0000016	0.0000351	−0.0000649
6	0.0000000	0.0000005	−0.0000006
L=30CM	D(1)	B(1)	C(1)
0	1.0000000	0.0014629	6.5548350
1	−1.8250200	−0.0010738	−12.3923000
2	1.0436290	0.0308962	8.0478930
3	−0.2023309	0.0294529	−1.748550
4	0.0103089	0.0071012	0.1075646
5	−0.0000842	0.0002442	−0.0013633
6	0.0000001	0.0000014	0.0000039

표 4.

Wall Composition — Shin Kgkusal BLD

No	Material	Thickness L (centimeter)	Conductivity K (kcal/M-Hr-Deg)	Diffusivity A (Sq-Meter/Hr)	Resistance R (Sm-Hr-Deg/kcal)	Capacity C (kcal/Sm-Deg)
	Surface air Film		8.0000		0.1250	
1.	Mortar	2.50	1.2000	0.002000	0.0208	15.0000
2.	Concrete	15.00	1.4000	0.002500	0.1071	83.9999
3.	Mortar	3.00	1.2000	0.002000	0.0250	18.0000
4.	Tile	1.00	0.7600	0.001280	0.0132	5.9375
	Surface air film		20.0000		0.0500	
	Total	L=21.50	U=2.9314		R=0.3411	C=122.9374

Indicial Response

No.	Alpha	Heat Flux A (Kanryu)	Heat Flux A (Kyusyu)	Surface Temperature A (Side-1)	Surface Temperature A (Side-2)
		2.93140	2.93140	0.63358	0.14657
1.	0.14422	−4.19166	2.93858	−0.36732	−0.20958
2.	−0.85414	1.81901	0.93945	−0.11743	0.09095
3.	2.43306	−0.86152	0.38992	−0.04874	−0.04308
4.	4.93456	0.48910	0.20698	−0.02587	0.02445
5.	8.38236	−0.31090	0.12715	−0.01589	−0.01555
6.	12.81731	0.21481	0.08365	−0.01046	0.01074
7.	18.21780	−0.16023	0.05703	−0.00713	−0.00801
8.	24.50255	0.12566	0.04070	−0.00509	0.00628

Z-Transfer Function Coefficients (Triangle Hold)

No	D(1)	B(1)	C(1)
0	1.0000000	0.0025530	6.5139341
1	−1.3865347	0.0391417	−9.9633389
2	0.4920632	0.1220646	4.0122681
3	−0.0359209	0.0392297	−0.3626359
4	0.0002409	0.0017601	0.0045320
5	−0.0000001	0.0000064	−0.0000083
6	0.0000000	0.000000	0.0000000

Z-Transfer Function Coefficients (Zeroth Hold)

No	D(1)	B(1)	C(1)
0	1.0000000	0.0000000	0.0000000
1	−1.3865347	0.0048046	5.9109230
2	0.4920632	0.1015558	−8.7997580
3	−0.0359209	0.0909653	3.3498087
4	0.0002409	0.0073859	−0.2580008
5	−0.0000001	0.0000401	0.0017828
6	0.0000000	0.0000008	−0.0000010

표 5. 손실열에 대한 Computer Program

Facom Bos/Vs Fostran S -770127- Vol-L14

Options in Effect (Fortsi)

Object, Nostack, Source, Nomap, Noisn, Ebcdic Noautodbl, Nosequence, Noasterisk, Nodenseprint, Opt(O), Fmtarea(256), Flag(W), Debug(STD)

```
      C     Heat Loss Calculation
0001        Dimension U(8), T(8), X(8)
0002        Dimension Cn(8), An(8)
0003        Dimension Xk(7)
0004        Read(5, 10) (U(N), N=1, 8)
0005        Read(5, 20) (T(N), X(N), N=1, 6)
0006        Read(5, 30) (Cn(N), An(N), N=1, 6)
```

```
0007            Read(5, 40) (Xk(N), N=1, 5)
0008            Read(5, 40) Width, Xlgth, Xhgth, Adoor, Awidw
0009            Read(5, 50) Ewn, Swn, Wwn, Xwn
0010            Read(5, 50) Edn, Sdn, Wdn, Xdn
0011            Read(5, 60) Tp, Xp, Te
0012         10 Format(8F10, 5)
0013         20 Format(2F10, 5)
0014         30 Format(2F10, 5)
0015         40 Format(5F10, 5)
0016         50 Format(4F10, 5)
0017         60 Format(3F10, 5)
        C       Calculation of Room Capacity
0018            V=Width*XLgth*Xhgth
        C       Print of Title
0019            Write (6, 110)
0020        110 Format (//15X, 25H** Heat Loss Calculation**)
0021            Write (6, 120)
0022            Write (6, 130)
0023        120 Format (//6X, 4H Time, 7X, 8H Sensible, 7X, 8H Humidify, 6X, 10H Total
                Load)
0024        130 Format (17X, 8H (kcal/H), 9X, 6H(kg/H), 7X, 8H (kcal/H)
0025            Do 1000 1=1, 6
0026            Ewall=U(1)* (Width*Xhgth)-Ewn*Awidw-Edn*Adoor)*(Tp-T(I))* Xk (1)
0027            Swall=U(2)*((XLgth*Xhgth)-Swn*Awidw-Sdn*Adoor)* (Tp-T(I))* Xk (2)
0028            Wwall=U(3)* ((Width*Xhgth)-Wwn*Awidw-Wdn*Adoor)* (Tp-T(I))* Xk(3)
0029            Xwall=U(4)* ((Xlgth*Xhgth)-Xwn*Awidw-Xdn*Adoor)* (Tp-T(I))* Xk(4)
0030            Roof=U(5) *Width*Xlgth* (Tp-T(I))* Xk(5)
0031            Door=U(6) *Adoor* (Edn* Xk(1)+Sdn*Xk(2)+Wdn*Xk(3)+Xdn*Xk(4)* (Tp-
                T(I))
0032            Wk=Ewn*Xk(1)+Swn*Xk(2)+Wwn*Xk(3)+Xwn*Xk(4)
0033            Dwidw=U(7) *Awidw*Wk*(Tp-T(I))
0034            Grnd=U(8) *Width*Xlgth*(Tp-Te)
0035            Tots=Fwall+Swall+Wwall+Xwall+Roor+Door+Dwidw+Grnd
0036            Vents=0.28* (Cn(I)+An(I)*V*(Tp-T(I))
0037            Toatal=Tots+Vents
        C       Calculation of Humidity
0038            Ventl=(Cn(I)+An(I)) *V*(Xp-X(I))* 715
0039            Hmdfy=(Cn(I)+An(I)) *V*(Xp-X(I))* 1.2
        C       Calculation of Machine-Load
0040            Totav=Total+Ventl
0041            A=6+2*1
0042            Write (6, 140) A, Total, Hmdfy, Totav
0043        140 Format (1H0, F10. 2, 5X, F10. 1, 5X, F10. 1, 5X, F10. 1)
```

```
0044        1000  Continue
0045              Stop
0046              End
```

FT 991 Data size=304, Procedure size= 1122
FT 994 No diagnostics generated (Ftmain)
FT 996 End of compilation (Ftmain)

표 6. 유입열에 대한 Computer Program

FACOM BOS/VS Fortran S -770127- Vol-L14

```
Options in Effect (Forts1)
    Object, Nostack, Source, Nomap, Noisn, Ebcdic, Noautodbl, Nosequence, Noasterisk,
            Nodenseprint, Opt(O), Fmtarea(256), Flag(W), Debug(STD)
C       Heat Gain Calculation
C       U; Heat Trasmission Coefficients.
C     T(I); Out Air Temp.
C       Tp; Indoor Air Temp.
C     X(I); Out Air Moisture Content.
C       Xp; Indoor Air Moisture Content.
C     Delt; Temperature Difference.
C      Igr; Solar Intensity.
C     Xuml; Watts of Lighting fixture
C      Xot; Motors
C      Off; Office Appliances
C     Peon; Number of People.
C       Cn; Air Change (Infiltration)
C       An; Air Change (Ventilation)
C       Wn; Number of Window
C       Db; Number of Door
C      Aks; Shading Coefficient.
C    Adoor; Area of One Door
C    Awidw; Area of One Window
C     Pcons; Sensible Heat of One People,
C     Pconl; Latent Heat of One People.
C     Width, Lenth, hight; Size of Room.
C      End; Enthalpy of out Air.
C     Hight; Hight of Wall
C     Width; Length of Wall Direction to N-S
C     Lenth; Length of Wall Direction to E-W
C      Vent; In filtration
C       Env; Enthalpy of Indoor Air.
```

```
0001        Implicit Real(L)
0002        Dimension U(8), T(8), X(8)
0003        Dimension Del T1(8), Del T2(8), Del T3(8), Del T4(8), Del T5(8)
0004        Dimension Eigr(8), Sigr(8), Wigr(8), Xigr(8)
0005        Dimension Peon(8), Xuml(8), Xot(8), O(8), Cffn(8), An(8)
0006        Read(5, 10) (U(N), N=1, 7)
0007        Read(5, 20) (Del T1(N), Del T2(N), Del T3(N), Del T4(N), Del T5(N),
            N=1, 5)
0008        Read(5, 30) (Eigr(N), Sigr(N), Wigr(N), Xigr(N), N=1, 5)
0009        Read(5, 60) (Peon(N), Xuml(N), Xot(N), Off(N), Cn(N), An(N), N=1, 5)
0010        Read(5, 40) (T(N), X(N), N=1, 5)
0011        Read(5, 10) Width, Lenth, Hight, Adoor, Awidw, Pcons, Pconl
0012        Read(5, 30) EWN, SWN, WWN, XWN
0013        Read(5, 30) EDN, SDN, WDN, XDN
0014        Read(5, 50) Aks, Tp, Xp
0015    10  Format (7F10, 5)
0016    20  Format (5F10, 5)
0017    30  Format (4F10, 5)
0018    40  Format (2F10, 5)
0019    50  Format (6F10, 5)
0020    60  Format (6F10, 5)
0021        ENP=0.24* Tp+Xp* (597.3+0.441* Tp)
0022        V=Width* Lenth* Hight
0023        Write (6, 110)
0024   110  Form at (/1H0, 35X, 27H*** Heat Gain Calculation*** //16X, 13H Sensible 1
            13H Latent, 13H Total, 13X, 13H Vent, 13H 2Vent, 13H Vent /3X, 13H Time,
            13H Heat, 13H 3 Heat, 13H Heat Gain, 13H Shf, 13H Sensible, 413H Latent
            13H Total, 13H Total, 9H Usrt/ 516X, 13H (kcal/Hr), 13H (kcal/Hr), 13H
            (kcal/Hr), 13X, 613H (kcal/Hr), 13H (kcal/Hr), 13H (kcal/Hr), 11H (kcal/Hr).
            710H R/T/)
0025        Do 1000 I=1,5
0026        Ewall=U(1)* ((Width*Hight)−EWN*Awidw−EDN*Adoor)* (Del T1(I))
0027        Swall=U(2)* ((Lenth*Hight)−SWN*Awidw−SDN*Adoor)* Del T2(I)
0028        Wwall=U(3)* ((Width*Hight)−WWN*Awidw−WDN*Adoor)*Del T3(I)
0029        Xwall=U(4)* ((Lenth*Hight)−XWN*Awidw−XDN*Adoor(* Del T4(I)
0030        Roof=U(5)* Width*Lenth*Del T5(I)
0031        Door=U(6)* Adoor* (EDN+SDN+WDN+XDN)* (T(I)−Tp)
0032        Dwidw=U(7)* (EWN+SWN+WWN+XWN)*Awidw* (T(I)−Tp)
0033        Tot S1=Ewall+Swall+Wwall+Xwall+Roof+Door+Dwidw
0034        Ewidw=EWN*Awidw*AKS*Eigr(I)
0035        Swidw=SWN*Awidw*AKS*Sigr(I)
0036        Wwidw=WWN*Awidw*AKS*Wigr(I)
0037        Xwidw=NWN*Awidw*AKS*Xigr(I)
```

```
0038            Tot S2=Ewidw+Swidw+Wwidw+Xwidw
0039            Peos=Peon(I)*Pcons
0040            Xligt=Xuml(I)*1000
0041            Vents=0.28*Cn(I)*V* (T(I)-Tp)
0042            Elec=(Xot(I)+Off(I))* 860.
0043            Tot S3=Peos+Xligt+Vents+Elec
0044            Tots=Tot S1+Tot S2+Tot S3
0045            Peol=Peon(I)* Pconl
0046            Ventl=715. *Cn(I)* V*(X(I)-Xp)
0047            Totl=Peol+Ventl
0048            Total=Tots+Totl
0049            Env=0.24*T(I)+X(I)* (597.3+0.441* T(I))
0050            Vent=1.2*An(I)*V* (Env-ENP)
0051            Total=Vent+Total
0052            Shf=Tots/Total
0053            Rfton=Totav/3024.
0054            Tvent=Vents+Ventl
0055            A=6+2*1
0056            Write (6, 120) A, Tots, Totl, Total, Shf, Vents, Ventl, Tvent, Totav, Rfton
0057       120  Format(1H0, 6X, F5.2, 5X, 3F13.2, F9.4, 4X, 5F 13.2/)
0058      1000  Continue
0059            Stop
0060            End
```

FT 991 Data Size=552, Procedure size=1575

FT 994 No Diagnostics Generated (Ftmain)

FT 996 End of Compilation (Ftmain)