MECH 4880 Coaching

Assignment Part A - Sections 6 and 7

Internal Loading

Overview of Today

- Where should I be up to in the assignment?
- What are internal loads?
- What is infiltration?
- How to calculate heat loads for lighting
- How to calculate heat loads for equipment
- How to calculate heat loads for occupants
- How to calculate heat loads for infiltration
- Comparing summer and winter internal loading
- What comes next?

Where Should I be up to in the Assignment?

Don’t forget that Assignment 1A is due next Friday (15th September)!!

If you are following along with the coaching sessions and are up to date you should have already completed sections 1-5. However lets do a quick recap of the major parts or problem areas:

- Section 1: Design days and daily/yearly temperature ranges
- Section 2: U value for ‘marble’ wall and roof, how to use the minimum R-value NCC values and storage masses
- Section 3: Heat loads through glass
- Section 4: Loads between spaces with the same temperature
- Section 5: Solar loading in winter

What are Internal Loads?

DA09 describes internal loads or internal heat gain as “the sensible and latent heat released within the air conditioned space by the occupants, lights, appliances, machines, pipes, etc”.

In simple terms this means any heat added to the room that is not from an external source.

Typically these loads are grouped into the main classes:

- People
- Lighting
- Equipment

Infiltration is normally presented along with internal loading but is not actually an internal load.

What is Infiltration/how to Calculate Infiltration Loads?

Infiltration represents the leakage or otherwise mixing of unconditioned outside air into the conditioned space.

Infiltration is always present in any building and can exist due to variety of reasons from gaps in window, wall or ceiling seals to open doors, vents and windows.

Infiltration due to leakage is calculated in DA09 using the following table:

TABLE 44—INFILTRATION DUE TO WIND FORCES

Parameter	Condition	Ch/h	Condition	Ch/h
Exposure	Sheltered	0	Exposed	$+\frac{1}{2}$
Construction	Wet	0	Dry	$+\frac{1}{2}$
Location of windows	1 wall or 2 adjacent walls	0	2 opposite walls, 3 or 4 walls	$+\frac{1}{2}$
Type of window	Gasketed	0	Not gasketed	$+\frac{1}{2}$
Degree of fenestration. (Openable window area per wall area)	Less 25%	0	50%	$+\frac{1}{4}$
Partitioning	Nil	0	Heavy	$-\frac{1}{2}$*

*Deductible only if the total air changes of the other parameters are equal to or greater than half.

What is Infiltration/how to Calculate Infiltration Loads?

This table as infiltration represented by Ch/h or air changes per hour. These units are a volumetric flow rate which represent the volume of the space being displaced in an hour. i.e. for a 50m^3 space with 2 AC/hour the infiltration flow rate will be 100m^3/hr of outside air.

Infiltration from open doors is often specified as an allowance in l/s which is dependent on how often the door is used and its size.

Excessive infiltration is a major concern as it can add significant heat and cooling loads in a conditioned space which is why many of todays structures and building codes pay particular attention to building seals.

Another common method of minimising infiltration loading is the use of air locks to create a pressurized zone so that conditioned air leaves the building rather than unconditioned air entering.

How to Calculate Heat Loads for Occupants

DA09 discusses heat loads due to occupants coming from three areas:

1. Radiation from the body surface to the surrounding surfaces
2. Convection from the body surface and the respiratory tract to the surrounding air
3. Evaporation of moisture from the body surface and in the respiratory tract to the surrounding air

So how do we calculate this?

Fortunately DA09 has a table which summarises all three of these loading cases into a single number for sensible and latent loading.

All you need to decide on is the activity level that the occupants are likely to be at.

How to Calculate Heat Loads for Occupants

TABLE 45—HEAT GAIN FROM PEOPLE

Degree of Activity	Typical Application	Metabolic Rate (Adult Male) Watts	Average Adjusted Metabolic Rate* Watts	ROOM DRY-BULB TEMPERATURE											
				28°C		27°C		26°C		24°C		22°C		20°C	
				Watts		Watts		Watts		Watts		Watts		Watts	
				Sens.	Lat.	Sens.	Lat.	Sens.	Lat.	Sens.	Lat.	Sens.	Lat.	Sens.	Lat.
Seated at rest	Theatre	115	100	50	50	55	45	60	40	67	33	72	28	79	21
Seated, very light work	High School	130	120	50	70	55	65	60	60	70	50	78	42	84	36
Seated, Standing	Office, Hotels	140	130	50	80	56	74	60	70	70	60	78	52	86	44
Standing, Walking Slowly	Dept., Retail Store	160													
Walking, Seated	Airport Terminal	160	150	53	97	58	92	64	86	76	74	84	66	90	60
Standing Walking Slowly	Bank	160													
Sedentary Work	Restaurant†	150	160	55	105	60	100	68	92	80	80	90	70	98	62
Light bench work	Factory, light work	230	220	55	165	62	158	70	150	85	135	100	120	115	105
Moderate Dancing	Halls, Ballrooms	260	250	62	188	70	180	78	172	94	156	110	140	125	125
Walking, 1.5 m/s	Factory, fairly heavy work	300	300	80	220	88	212	96	204	110	190	130	170	145	155
Heavy Work	Factory	440	430	132	298	138	292	144	286	154	276	170	260	188	242

*Adjusted Metabolic Rate is the metabolic rate to be applied to a mixed group of people with a typical percent composition based on the following factors:
Metabolic rate, adult female = Metabolic rate, adult male × 0.85
Metabolic rate, child = Metabolic rate, adult male × 0.75

†Restaurant—Values for this application include 20 watts for food per individual (10 watts sensible and 10 watts latent heat).

How to Calculate Heat Loads for Equipment

Heat loads due to equipment are simpler, all that needs to be done is to find the sensible and latent loads that each piece of equipment gives off and to sum them. A typical list of equipment can be found in DA09 or ASHRAE and look like the following:

TABLE 46—HEAT GAIN FROM PANTRY OR TEA ROOM EQUIPMENT
ELECTRIC HEATED—NOT HOODED*

Appliance	Type of Control	Miscellaneous Data	Manuf. max. Ratings kW	Recommended heat gain for average use		
				Sensible kW	Latent kW	Total kW
Boiling Water Urn 5 ℓ	Simmerstat or Man.	Single heat control	1.510	0.6	0.3	0.9
5 ℓ	Simmerstat or Man.	Three heat control	2.000	0.8	0.4	1.2
10 ℓ	Simmerstat or Man.	Three heat control	2.000	0.8	0.4	1.2
20 ℓ	Simmerstat or Man.	Three heat control	2.420	1.0	0.5	1.5
30 ℓ	Simmerstat or Man.	Three heat control	3.620	1.5	0.7	2.2
40 ℓ	Simmerstat or Man.	Three heat control	3.620	1.5	0.7	2.2
50 ℓ	Simmerstat or Man.	Three heat control	3.620	1.5	0.7	2.2
2x10 ℓ	Simmerstat or Man.	Three heat control	3.620	1.5	0.7	2.2
Boiling Top 150 mm dia.	Auto. or Man.	Coil type heavy duty	1.260	0.6	0.2	0.8
160 mm dia.	Auto. or Man.	Coil type heavy duty	1.510	0.6	0.3	0.9
200 mm dia.	Auto. or Man.	Coil type heavy duty	2.110	0.9	0.4	1.3
160 mm dia.	Auto. or Man.	Cast Plate	1.000	0.4	0.2	0.6
200 mm dia.	Auto. or Man.	Cast Plate	1.815	0.8	0.3	1.1
Griddle Plate 250 mm x 200 mm	Auto. or Man.	Coil Type	2.000	0.8	0.4	1.2
300 mm x 250 mm	Auto. or Man.	Coil Type	2.785	1.2	0.5	1.7
450 mm x 250 mm	Thermostat	Plate Type	2.420	1.0	0.5	1.5
450 mm x 400 mm	Thermostat	Plate Type	4.425	1.9	0.8	2.7
Bain Marie 2 x 7 ℓ pots	Simmerstat	Counter type	0.850	0.3	0.2	0.5
4 x 7 ℓ pots	Simmerstat	Counter type				
6 x 7 ℓ pots	Simmerstat	Mobile	1.500	0.6	0.3	0.9
6 x 7 ℓ pots & hot press	Thermostat	Mobile	3.000	1.3	0.5	1.8
6 x 7 ℓ pots, 1—250 mm x 200 mm meal dish & hot press	Thermostat	Mobile	2.400	1.0	0.4	1.4
Hot Trolley	Thermostat	Bulk Supplies 30 people	2.400	1.0	0.4	1.4
	Thermostat	Plated service 30 people	2.400	1.0	0.4	1.4
Dispensers 190 mm plates	Thermostat	Single Tube	0.38	0.1	0.1	0.2
	Thermostat	Double Tube	0.75	0.3	0.2	0.5
	Thermostat	Four Tube	1.50	0.6	0.3	0.9
Dishwasher 1000 pieces/hour 250 mm dinner plate		Rotary for crockery only, Electric boost Water 270 ℓ/h at 85°C	3.0 / 15.0 } 18.0	7.5	7.5	15.0
Glasswasher 1000 glasses/hour		Rotary basket, Electric boost Water 270 ℓ/h at 85°C	3.0 / 15.0 } 18.0	7.5	7.5	15.0
Toaster 6 slice	Variable	Bench mounted	3.160	1.3	0.6	1.9
12 slice	3 heat variable	Bench mounted single deck	3.600	1.5	0.7	2.2
Continuous 360 slices/hour	3 heat variable	Bench mounted rotary	4.100	2.4	1.1	3.5
Continuous 450 slices/hour	Variable	Horizontal type	3.000	1.8	0.8	2.6
Food Warmer 36 pies	Simmerstat	Bench Mounted	1.000	0.4	0.2	0.6
60 pies	Simmerstat	Bench Mounted	1.500	0.6	0.3	0.9
100 pies	Simmerstat	Bench Mounted	2.000	0.8	0.4	1.2
Stoves 3 plate	Auto.	Domestic type with coil plates	9.300	3.9	1.7	5.6
4 plate	Auto.	Domestic type with coil plates	11.500	4.8	2.1	6.9

How to Calculate Heat Loads for Lighting

Lighting generally makes up a significant proportion of the heat loads in a building (10-20%). As a result Australian building codes have several restrictions on lighting density (W/m^2) to ensure that excessive amounts of energy is not spent on having excessive lighting only to have to cool the space due to the additional lights.

Unfortunately calculating lighting loads is not quite as straight forward as equipment loading. This is due to the location of the lighting itself, that is in the ceiling space or just below it.

This means that the space itself holds some of the heat load releasing it over time in similar way to solar loading.

As a result to calculate lighting loads you need to know both the storage mass and the type of light fitting in the space and consult the following table and its corrections.

How to Calculate Heat Loads for Lighting

TABLE 11—STORAGE LOAD FACTORS, HEAT GAIN, LIGHTS*

Lights on 10 Hours† with Equipment Operating 12, 16 and 24 Hours, Constant Space Temperature

	Equipment Operation Hours	Mass per‡ unit area of floor kg/m²	Number of hours after lights are turned on																							
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Fluorescent Lights Exposed	24	700 & over	0.36	0.67	0.71	0.74	0.76	0.79	0.81	0.83	0.84	0.86	0.87	0.29	0.26	0.23	0.20	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.08
		500	0.31	0.67	0.72	0.76	0.79	0.81	0.83	0.85	0.87	0.88	0.90	0.30	0.26	0.22	0.19	0.16	0.15	0.13	0.12	0.10	0.09	0.08	0.07	0.06
		150	0.25	0.74	0.83	0.88	0.91	0.94	0.96	0.96	0.98	0.98	0.99	0.26	0.17	0.12	0.08	0.05	0.04	0.03	0.02	0.01	0.01	0.01	0	0
	16	700 & over	0.58	0.82	0.83	0.84	0.84	0.85	0.85	0.85	0.86	0.88	0.90	0.32	0.28	0.25	0.23	0.19								
		500	0.46	0.79	0.84	0.86	0.87	0.88	0.88	0.89	0.89	0.90	0.90	0.30	0.26	0.22	0.19	0.16								
		150	0.29	0.77	0.85	0.89	0.92	0.95	0.96	0.96	0.98	0.98	0.99	0.26	0.17	0.12	0.08	0.05								
	12	700 & over	0.63	0.90	0.91	0.93	0.93	0.94	0.95	0.95	0.95	0.96	0.96	0.37												
		500	0.57	0.89	0.91	0.92	0.94	0.94	0.95	0.95	0.96	0.96	0.97	0.36												
		150	0.42	0.86	0.91	0.93	0.95	0.97	0.98	0.98	0.99	0.99	0.99	0.26												
Fluorescent Lights Recessed in Suspended Ceiling or Exposed Incandescent Lights	24	700 & over	0.32	0.55	0.61	0.65	0.68	0.71	0.74	0.77	0.79	0.81	0.83	0.39	0.35	0.31	0.28	0.25	0.23	0.20	0.18	0.16	0.15	0.13	0.12	0.11
		500	0.24	0.56	0.63	0.68	0.72	0.75	0.78	0.80	0.82	0.84	0.86	0.40	0.34	0.29	0.25	0.20	0.18	0.17	0.15	0.14	0.12	0.10	0.09	0.08
		150	0.17	0.65	0.77	0.84	0.88	0.92	0.94	0.95	0.97	0.98	0.98	0.35	0.23	0.16	0.11	0.07	0.05	0.04	0.03	0.02	0.01	0.01	0	0
	16	700 & over	0.57	0.75	0.79	0.80	0.80	0.81	0.82	0.83	0.84	0.86	0.87	0.39	0.35	0.31	0.28	0.25								
		500	0.46	0.73	0.78	0.82	0.82	0.82	0.83	0.84	0.85	0.87	0.88	0.40	0.34	0.29	0.25	0.20								
		150	0.22	0.69	0.80	0.86	0.89	0.93	0.94	0.95	0.97	0.98	0.98	0.35	0.23	0.16	0.11	0.07								
	12	700 & over	0.67	0.86	0.89	0.90	0.91	0.91	0.92	0.93	0.94	0.95	0.95	0.50												
		500	0.58	0.85	0.88	0.88	0.90	0.92	0.93	0.94	0.94	0.94	0.95	0.48												
		150	0.40	0.81	0.88	0.91	0.93	0.96	0.97	0.97	0.98	0.99	0.99	0.35												
Fluorescent or Incandescent Lights Recessed in Suspended Ceiling and Ceiling Plenum Return System	24	700 & over	0.22	0.33	0.41	0.47	0.52	0.57	0.61	0.66	0.70	0.73	0.74	0.59	0.52	0.46	0.42	0.37	0.34	0.31	0.27	0.25	0.23	0.21	0.18	0.16
		500	0.17	0.33	0.44	0.52	0.56	0.61	0.66	0.69	0.74	0.77	0.79	0.60	0.51	0.44	0.37	0.32	0.30	0.27	0.23	0.20	0.18	0.16	0.14	0.12
		150	0	0.48	0.66	0.76	0.82	0.87	0.91	0.93	0.95	0.97	0.98	0.52	0.34	0.24	0.16	0.11	0.07	0.05	0.04	0.02	0.02	0.01	0	0
	16	700 & over	0.56	0.64	0.68	0.72	0.73	0.73	0.75	0.75	0.76	0.76	0.78	0.59	0.52	0.46	0.42	0.37								
		500	0.47	0.60	0.67	0.72	0.74	0.77	0.78	0.79	0.80	0.81	0.82	0.60	0.51	0.44	0.37	0.32								
		150	0.07	0.53	0.70	0.78	0.84	0.88	0.91	0.93	0.95	0.97	0.98	0.52	0.34	0.24	0.16	0.11								
	12	700 & over	0.75	0.79	0.83	0.84	0.86	0.88	0.89	0.91	0.91	0.93	0.93	0.75												
		500	0.68	0.77	0.81	0.84	0.86	0.88	0.89	0.89	0.92	0.93	0.93	0.72												
		150	0.34	0.72	0.82	0.87	0.89	0.92	0.95	0.95	0.97	0.98	0.98	0.52												

Comparing Summer and Winter Internal Loading

The main difference between summer and winter internal loading is due to two major influences:

1. **Design day**
   There are several things we consider in the design day which are different between winter and summer such as: time of year, time of day, internal/external temperature, etc.

2. **Representation of the worst case scenario**
   It is important to understand what assumptions are made around the summer internal loading calculations and if they apply or are modified to suit the winter loading case. Another consideration should be what things to we allow to reduce the cooling load requirements (summer)? Can we allow similar items to reducing the heating load requirements (winter)?

What Comes Next?

Over the next two weeks you should aim to meet the following goals:

- If you haven't done so already you need to complete sections 1-5 ASAP
- Over the course of this week aim to complete sections 6 and 7
- Section 8 should be a simple compilation of all the hand calculations you have done, which hopefully are in a spreadsheet (don't forget you should fully type out a least one of each unique calculation before presenting the final results for each section)
- Section 9 should be the same as many of the lecture examples and tutorial questions since you will have the outside air flow rate, total latent load, total sensible load, supply air condition and coil contact factor.
- Section 10 will be discussed in further detail in next weeks coaching session with a live CAMEL session in the lecture to please bring along a device with CAMEL installed