3.0 Design Parameters

There are certain parameters that need to be addressed in mechanical design. These parameters include the heating and cooling loads for the building, the required ventilation rates, and a few other factors inherent to the building and location. The following sections include the parameters that the final design must meet, regardless of which system is selected.

3.1 Ventilation

AHSRAE Standard 62.1-2004 governs the minimum ventilation air rate requirements for buildings. The spaces inside of LA Fitness are very diverse in both function and size. For this reason, a thorough analysis of ventilation rates for this building had to be performed.

Space	Area (ft^2)	Design Occupancy
Aerobics	3083	61.7
Racquetball	835	4
Racquetball	835	4
Racquetball	835	4
Racquetball	835	4
Racquetball	835	4
Child Restrooms	148	1.2
Storage	228	0
Kid's Club	1840	36.6
Free Weights	2974	59.5
Basketball	3810	20
Storage	460	8.8
Sp. Exercise	1366	27.3
Equipment Room	147	0.5
Cardiovascular	10520	210.4
Mezzanine	3000	60
Trainer's Office	217	2.7
Spinning	1141	22.8
Pool Equipment	290	1
Pool & Spa	4112	82.3
Locker Rooms	4125	8.8
Reception	1420	14
Membership Sales	687	8
Juice Bar	280	2.6

Table 3.1 Space Function, Area, and Occupancy

The ventilation rate procedure was utilized to find the required minimum outdoor air for each of the thirteen rooftop units. It is assumed that air mixes perfectly in these calculations. The total mixed air supply for the original design is 84,000 cfm that contains 19.4% outdoor air for ventilation purposes. The results from the Standard 62.1 calculation show that the building requires 20.9% outside air if the same total supply cfm is used. While these numbers are approximately equal, they only represent the total percentage requirements for the building. When each rooftop unit is examined, it can be seen that only 3 of the 11 units (RTU-1, 4, and 5) have enough ventilation air for the zones that they each serve.

	V_{oz}	V_{ot}	Actual Design OA	Total Airflow	Design %OA	62.1n %OA
RTU-1	154	154	500	5000	10.0	3.1
RTU-2	950	1188	700	5000	14.0	23.8
RTU-3	3620	3620	3500	10500	33.3	34.5
RTU-4	807	807	3350	8300	40.4	9.7
RTU-5	629	629	750	7500	10.0	8.4
RTU-6	1368	1368	750	6000	12.5	22.8
RTU-7	1419	1419	1000	10000	10.0	14.2
RTU-8	651	651	500	4000	12.5	16.3
RTU-9	2420	2420	1675	6600	25.4	36.7
RTU-10	2420	2420	1675	6600	25.4	36.7
RTU-11	944	1049	750	5500	13.6	19.1
RTU-12	524.5	524.5	500	3500	14.3	15.0
RTU-13	1380	1380	750	5900	12.7	23.4
Entire Building	17286	17628	16400	84400	19.4	20.9

Table 3.2 – Comparison of 62.1 Required OA and Actual Design OA for LA Fitness

These findings show that the new design will need to provide adequate ventilation air to each zone that is being served on a space by space method instead of looking at the entire building totals.

3.2 Heating and Cooling Loads

Houston, TX is a relatively hot location, especially on design days. The 2005 ASHRAE Handbook of Fundamentals was used to find the design day temperature conditions.

	Cooling		Heating
	Dry Bulb	Wet Bulb	Dry Bulb
Fort Bend County, Houston, TX	96.9	80.1	27.7

Table 3.3 – 0.4% and 99.6% Design Conditions from ASHRAE Handbook

The design documents from the original design provided the heating and cooling loads that were found for each of the thirteen rooftop units. Those loads can be seen below in Table 3.3. These loads give an accurate “ballpark figure” as to what type of cooling demand needs to be met at the site. Most of the space loads have a very high latent percentage. This is a result of the activity that takes place inside of the building; besides having an indoor pool and a locker room, the facility houses other high latent activities such as basketball, racquetball, aerobics, and other cardiovascular exercises that cause people to breathe heavily and also to produce sweat.

General Description			Fan Section		Heating Section		Cooling Section		
Unit	Area Served	Energy Used (MBh)	Total Air (cfm)	Outside Air (cfm)	Output (MBh)	Efficiency (%)	Sensible (MBh)	Total (MBh)	Temperature Leaving Unit (F)
RTU-1	Reception	250	5000	500	203	81	119.5	162.0	58.6
RTU-2	Kid's Club	250	5000	700	203	81	102.0	145.8	58.6
RTU-3	Pool	500	10500	3500	400	80	223.3	302.4	58.0
RTU-4	Lockers	350	8300	3350	284	81	136.0	168.1	60.5
RTU-5	Basketball	250	7500	750	203	81	159.8	226.5	58.3
RTU-6	Free Weights	250	6000	750	203	81	133.8	199.2	55.2
RTU-7	Aerobics	500	10000	1000	400	80	220.3	319.5	56.5
RTU-8	Racquetball	150	4000	500	122	81	79.0	118.6	57.6
RTU-9	Cardio	400	6600	1675	324	81	161.5	250.1	56.9
RTU-10	Cardio	400	6600	1675	324	81	161.5	250.1	56.9
RTU-11	Lower Stairs	250	5500	750	203	81	120.0	172.0	57.1
RTU-12	Spinning	150	3500	500	122	81	80.8	117.8	57.7
RTU-13	Mezzanine	250	5900	750	203	81	133.8	199.2	55.2

Table 3.4 – Original Design Rooftop Unit Abridged Schedule (See Appendix A for Full Schedule)

Using Trane’s energy simulation calculator, TRACE, a model was set up to simulate the thermal loads on the building. The model was updated to include the correct ventilation rates that will meet ASHRAE Standard 62.1-2004. Also, other factors were accounted for such as the sensible heat gain from equipment such as treadmills and exercise bikes. The treadmills were simulated to each have a sensible heat output of 590 Btu/hr. This estimation was found in the 2005 ASHRAE Handbook of Fundamentals.

Zone:	Equipment Load	Exercise Loads/Person	
	Sensible	Sensible	Latent
Cardio	8910	350	500
Racquetball	0	350	500
Basketball	0	710	1090
Free Weights	0	350	500
Aerobics	0	710	1090
Spinning	6138	710	1090
Mezzanine	5940	710	1090

Table 3.5 – Modified 2005 ASHRAE Fundamentals Heat Gains for Spaces

The results of this more detailed model showed that the rooftop units may have been oversized beyond standard safety factors. The thought process that preceded the over-sizing of the units is discussed at greater length in Section 8.0 of this report.

3.3 Critical Zones

The indoor pool and the locker room need to be evaluated with special care. The pool area needs to be kept at a lower pressure than the adjacent zones in the final design. The rationale behind this decision is to ensure that there is not humid air being transferred into the reception/lobby area that is located next to the pool. If such a transfer were to occur there would be issues of mold, odor, and an increase of latent load on the zone. The locker room will also need to be designed slightly negative compared to the adjacent spinning and exercise rooms for the same reasons.

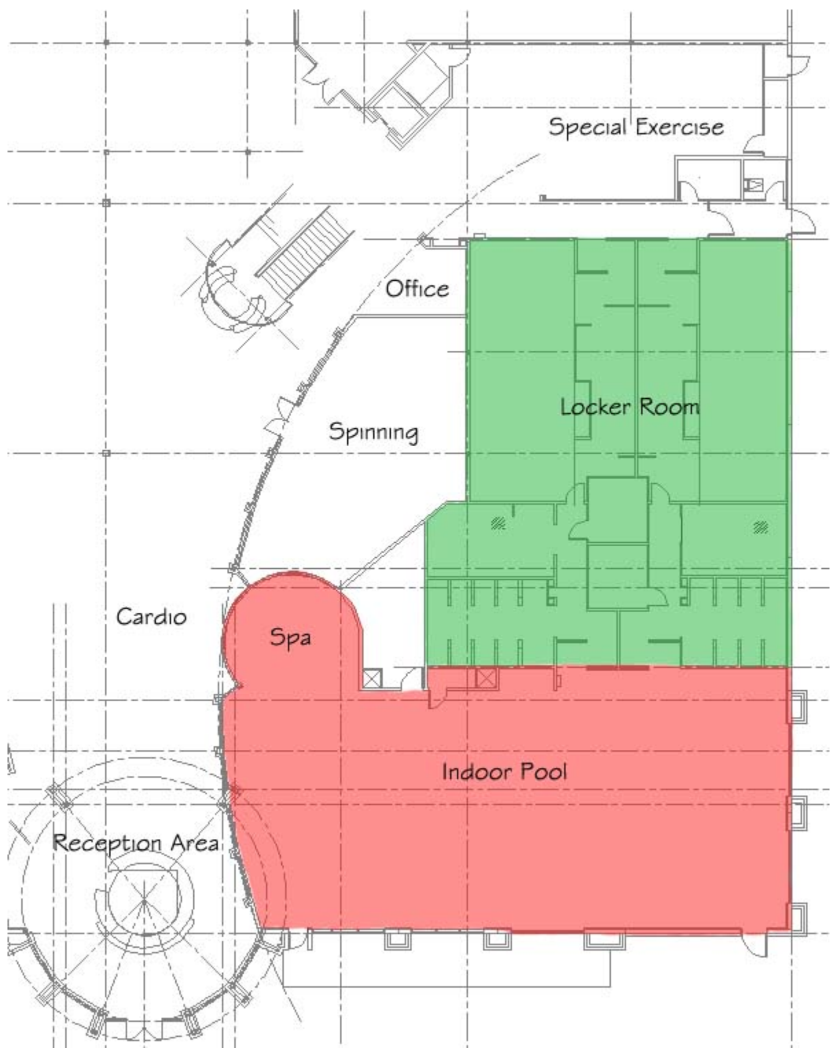

Figure 3.1 – Colored Zones are Critical Spaces for Pressure Balance

3.3.1 Indoor Pool Design

Maintaining adequate humidity levels and dry bulb temperatures to indoor pools presents a unique design challenge. Design loads calculations for natatoriums have to take into consideration all of the normal load parameters such as envelope, lighting, and outdoor air, as well as the loads from occupants and the very high latent load associated with the evaporation of water. ASHRAE has found that swimmers are most comfortable with dry bulb temperatures ranging from 78 to 85 ^{0}F and relative humidity levels ranging from 50% to 60%. With this in mind, the original design supplied air at 80^{0}F and 55% relative humidity. The pool water is maintained at 82^{0}F; a comfortable temperature adequate for recreational or competitive use. At these conditions, the evaporation rate of water was found to be 102.9 lb/hr. This evaporation rate correlates to a latent load of 102,938 Btu/hr. The equation and values used for this calculation can be found in Appendix B. The additional latent load from the pool will considerably lower the sensible heat ratio for this space and will need to be addressed in any good design. The 2003 ASHRAE Handbook of HVAC Applications suggests that there be an air change rate of four to six air changes per hour for this type of space.

3.4 Building Envelope

Section 5 of ASHRAE Standard 90.1-2004 was established to ensure that buildings are not wasting energy through poor building envelope design. The standard provides minimum insulation values for the walls, floors, and roof, and these values or designated by climate zones. The standard also addresses the issue of high solar load through glazing by providing minimum U-values and a solar heat gain coefficient to ensure that there is not too much heat gain from the sun.

The opaque areas of the building were analyzed using the prescriptive building envelope option. In the design documents, the architect calls for a roof assembly that was calculated to have an R-24 insulation value. This assembly exceeds the R-15 minimum that the standard requires. The floor system in place has an R-value of 22 which will satisfy the R-19 requirement between floors.

Item	Description	Insulation Min.
		R-Value
Roofs	Insulation Entirely above Deck	R-15.0
Mass Walls	8" Tilt-wall construction with 2" insulation	Not Required
Floors	Steel Joist	R-19.0
Slab-On-Grade Floors	Unheated	-
Opaque Doors	Swinging	-

Table 3.6 – Opaque Building Envelop Compliance

There are two major factors used when evaluating fenestration: the U-value and the solar heat gain coefficient. The windows used in this design have a U-value of 0.95 Btu/h-ft^2-^{o}F, which complies because it is lower than the standard's maximum U-value of 1.22. The standard also requires that the total vertical fenestration area is to be less than 50% of the gross wall area. Table 3.7 below shows that this construction far exceeds those criteria as well. The windows had a solar heat gain coefficient of 0.23; this value, while close to the limit, does comply with the standard.

Fenestration	Operable/Fixed	% Glazing	Assembly Max. U	SHGC
North	All Fixed	6.96	1.22	0.61
South	All Fixed	6.96	1.22	0.25
East	All Fixed	3.86	1.22	0.25
West	All Fixed	24.9	1.22	0.25

Table 3.7 – ASHRAE Standard 90.1-2004 Fenestration Requirements