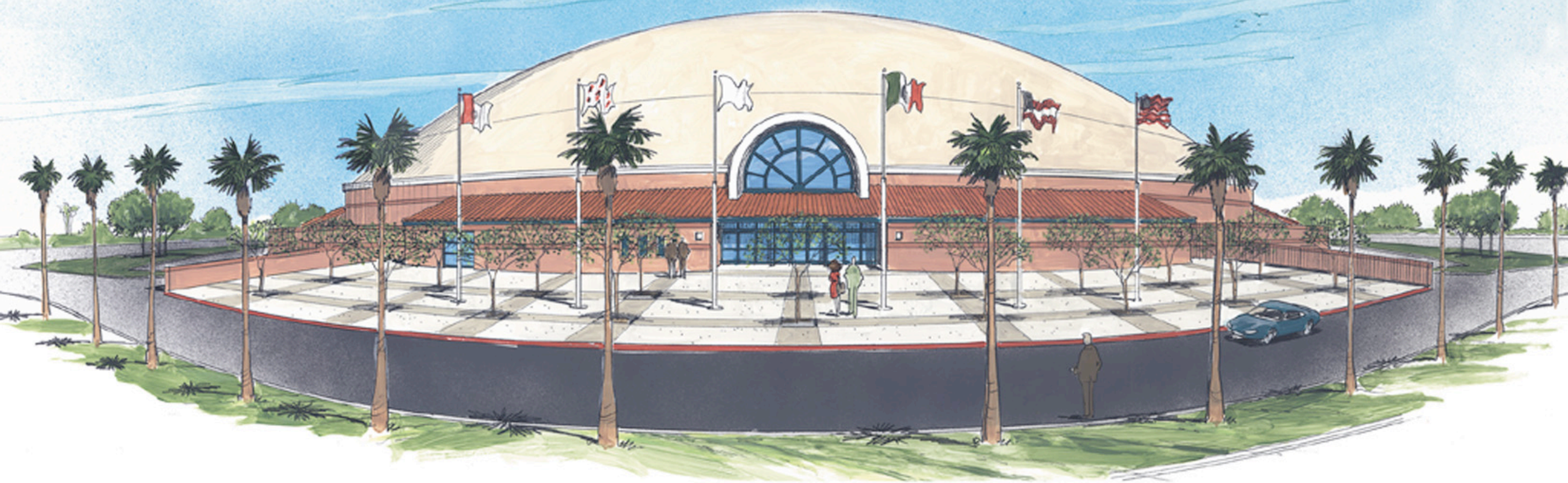
MONOLITHIC DOME INSTITUTE
177 Dome Park Place
Italy, TX 76651
972-483-7423

ARENA PAK

ARENA



Monolithic Dome
Diameter 280 Feet
Height 74 feet
Stem wall 16 feet
Total Height 90 feet
Circumference 899 feet

Monolithic Dome Airform
Surface area 78,779 SF
Weight 25,500 pounds

Polyurethane foam
volume 236,335
weight 73,000 pounds

Spray Applied Concrete
volume 2,000 Cubic Yards
Weight 7,6000,000

Outer Structure
as Needed

Ice Hockey
capacity 6,500 seats
rink 85 feet x 200 feet

Basket Ball
Capacity 8,000 seats
court 50 feet x 94 feet

Arena Football / Soccer
capacity 6,000 seats
field 85 feet x 240 feet

Circus / Rodeo / Truck Pulls
capacity 6,000 seats
floor 85 feet x 200 feet

Concerts
capacity 8,000 seats
center stage 20 feet x 40 feet

Features
clubhouse, retail & leasable spaces, sky boxes (optional), administration, storage & mechanical rooms, shops, concessions, ticket booths, first aid, security, radio station, restrooms, press boxes, locker rooms, coaches offices, conference rooms, meeting rooms, auxiliary rooms

Avalon Multipurpose Center — Avalon, TX

Avalon Multipurpose Center

Facility: Avalon Gym and Multi-purpose Center

Architect: Frederick Crandall

Engineer: Dr. Arnold Wilson

Builder: Monolithic Construction Management, Monolithic Constructors, and Dome Technology

Description: 124' x 25' dome on a 12' stemwall - 11,500 square feet. Copper color dome. Came in under budget and on time. Approved by FEMA for protection from storms. 720 seats.

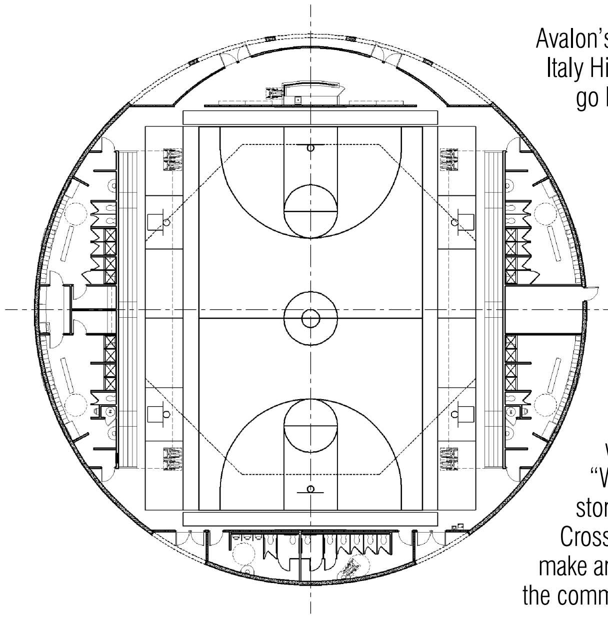
Owner: Avalon Independent School District

Location: Avalon, Texas

Cost: $1.2 Million - $110 per square foot

Started: January 2002

Completed: January 2003



Avalon's nearness to and familiarity with the Italy High School Gym made the decision to go Monolithic fairly easy.

School Superintendent David Del Bosque said, "We went over and really looked at Italy. And we were really impressed with what the long-term savings would be -- utilities, maintenance and that kind of thing. I personally was concerned about safety for students: the stability of the building in case of a storm."

"This is the safest structure anywhere here," Del Bosque continued. "We plan to use it also as a community storm shelter. We'll contact the Red Cross, get it certified as a shelter, and make arrangements for somebody here in the community to have a key to open it up in an emergency."

PHOTOS BY DAVID SOUTH JR

Gymnasium

Gladiator Coliseum — Italy, TX

Facility: Italy High School Multi-purpose Center

Architect: Frederick Crandall

Engineer: Dr. Arnold Wilson

Builder: Monolithic Construction Management and Dome Technology

Description: Monolithic Dome, two-story, 148' diameter as Multipurpose Center, that includes gymnasium with walking track, seating for 1500, auditorium, classrooms for special activities and concrete parking area and drives.

Owner: Italy Independent School District

Location: Italy, Texas

Cost: $2 Million - $85 per square foot

Started: December 18, 2000

Completed: January 15, 2002

The Italy Gladiators use this Multipurpose Center for basketball and volleyball, and the general school population uses it for physical education, theatrical performances and a variety of other activities.

The gym has also been designated as the school and the community disaster shelter.

Italy High chose a high, two-story design easily identified with dome arenas, and includes two levels of seating, concession stands, ticket booths, four locker rooms, public restrooms and four coaches offices.

One of the dome's features the athletes enjoy most is its maple, parquet floor laid in the famous Boston Gardens pattern.

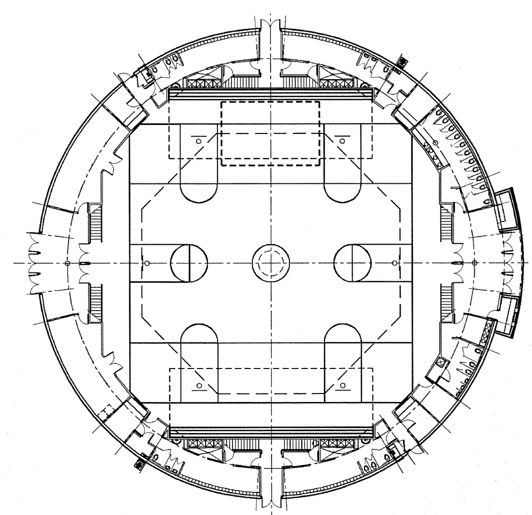
Scoreboard and hung ceiling are secured to the dome shell. Above the hung ceiling is the catwalk providing access to the sound system and HVAC systems.

Gymnasium

Italy Basketball

PHOTOS BY DAVID SOUTH JR

Italy Multipurpose Center



Payson Multipurpose Center — Payson, AZ

Facility: Payson Multi-purpose Center

Architect: Frederick Crandall

Engineer: Robert Hatch and Brad Crane

Builder: Dome Technology

Description: 200' diameter. Seats 2500 people.

Owner: Payson School District

Location: Payson, Arizona

Cost: $2.5 Million ($67 per square foot)

Started: 1995

Completed: 1996

The gymnasium is the center of the facility. The 200 foot diameter dome can seat 2,500 people.

The dome features one competition court that splits into two practice courts. There is additional space for a wrestling room, rest rooms, weight rooms, concessions, as well as four coaches' offices, two sets of boys' and girls' locker rooms and storage space.

Assistant Principal and Athletic Director Barry Smith said he is impressed by the dome's construction and floor plan. "The layout couldn't be better. They took a square gym and put it into a round building, and it is great."

District Superintendent Russ Kinzer said the new sports complex only cost about $2.8 million, as opposed to the $5 or $6 million it would have cost for a comparable building built with traditional methods.

2500 Seat Gymnasium

"The layout couldn't be better. They took a square gym and put it into a round building, and it is great."

Wrestling Room

Entry / Concessions

Payson Multipurpose Center

PHOTOS BY STEVEN CUTTER

Breckon Sports Center — Parkville, MO

Facility: Breckon Sports Center

Architect: Frederick Crandall

Engineer: Dr. Arnold Wilson

Builder: Dome Technology

Description: Twin Monolithic Dome gymnasiums, each 130' diameter. One dome provides a competition gymnasium and the other a practice gym. The entire facility encompasses 31,891 square feet and provides seating for 1,000 spectators.

Owner: Park University

Location: Parkville, Missouri

Cost: $3.4 Million (not including site development) — $107 per square foot

Started: Summer 1999

Completed: Summer 2000

Sports are a big thing at Park. The University's men's and women's teams compete in the NAIA (National Association of Intercollegiate Athletics) in basketball, volleyball, soccer and softball. The performance gym with its 1000 spectator seats — hosts competitions and special events.

Asked how he likes the domes, Athletic Director Claude English said, "Well, I'll be honest with you. There's not much at all that I dislike. The actual facility is wonderful. You always look back and think about storage and things of that nature, but the actual facility — the office space, the locker rooms, the gyms — they're all very good." According to English, he and the coaches appreciate the practice gym as much or even more than the performance gym.

He said, "We now have a facility to practice in. No more cancellations because of bad weather. It's wonderful because we have terrible winters. It's been a dream come true."

COURTESY OF PARK UNIVERSITY

Breckon Sports Center

INTERIOR PHOTOS BY DAVID COLLINS

Main Gymnasium

Practice Gymnasium

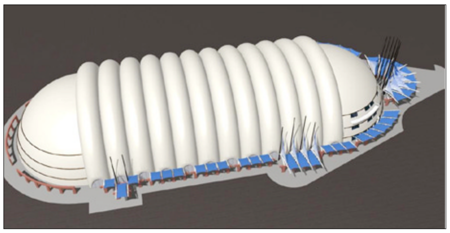
Indoor Practice Football Field

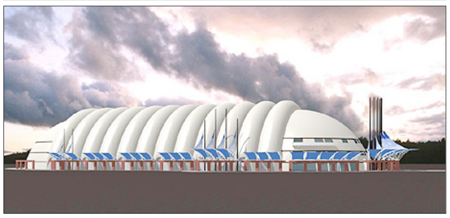
Facility: Proposed Indoor Practice Football Field

Architect: Leland Gray

Engineer: Dr. Arnold Wilson

Description: Facility designed for football practice. Space includes coaches offices, meeting rooms, trophy room and an alumni gathering area.





RENDERINGS BY LELAND GRAY

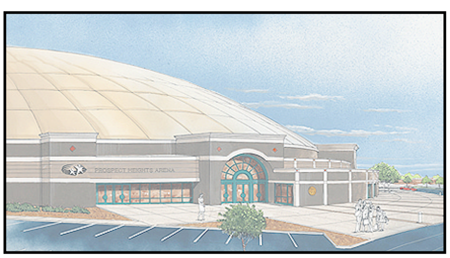
Ice Arena Concept

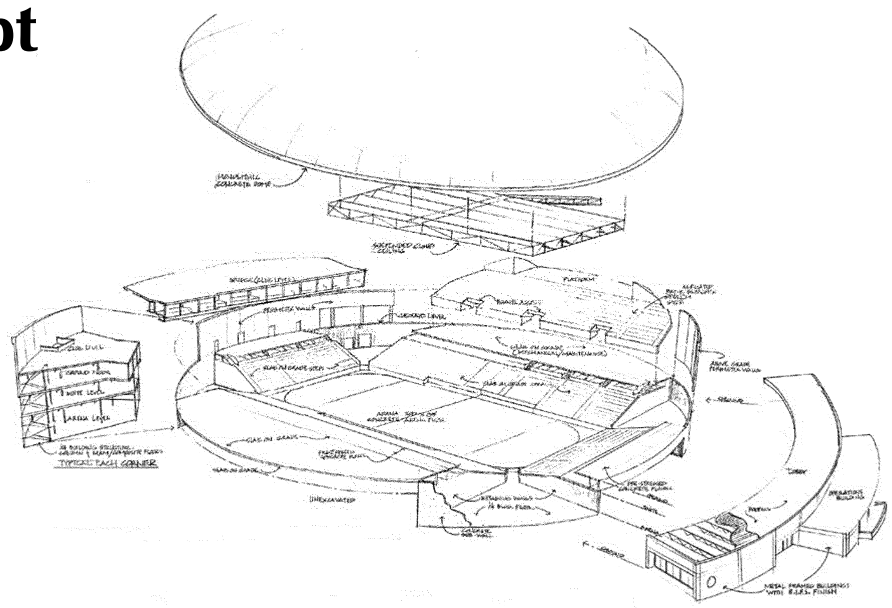
Facility: Proposed Ice Arena

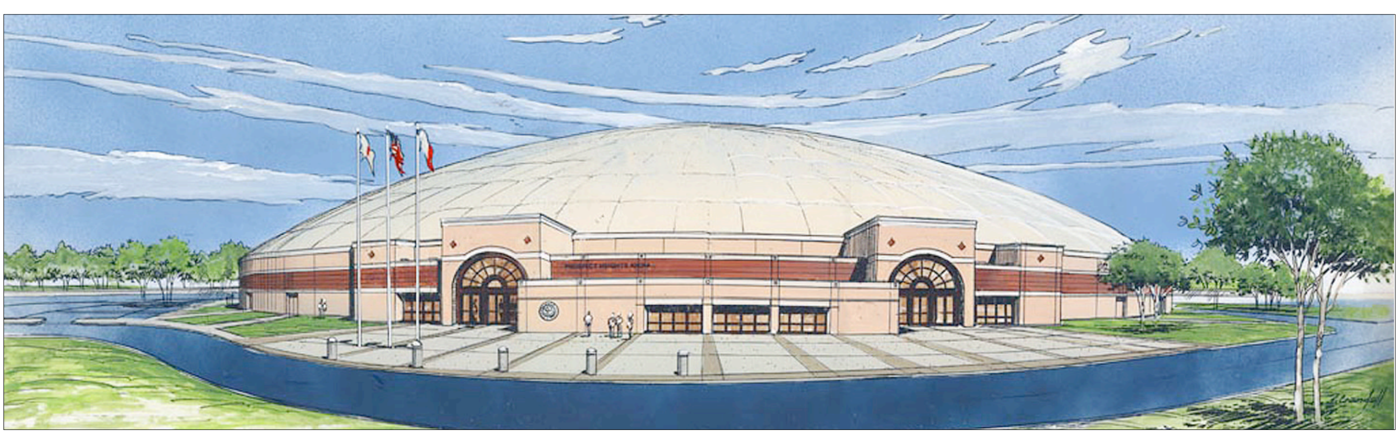
Architect: Frederick Crandall

Engineer: Dr. Arnold Wilson

Description: Designed for pro-hockey with the ability to host basketball games and concerts. Fifteen thousand seats, 100 skyboxes, 1000 club seats plus restaurants, snack bars, and commercial areas.







RENDERINGS AND LAYOUT BY RICK CRANDALL

The Ultimate Sports Facility

RICK CRANDALL

Facility: Football Stadium

Architect: Frederick Crandall

Engineer: Dr. Arnold Wilson

Description: 400' diameter with seating for 8,000. Crenosphere technology for dome construction.

Possible Uses: As 25,000-seat stadium for ice hockey, arena football, softball, or concerts and as a convention or civic center.

Crenosphere Domes are huge, concrete structures ideally suited for indoor sports. Their diameters range from 300 to 1000 feet; their heights range from 75 to 500 feet. They can accommodate thousands of spectators and a virtually limitless number of activities. But—here's the best part—Crenosphere Domes are affordable and practical.

Significantly Lower Construction Costs – In some situations, the cost of building a Crenosphere could be half the construction cost of other types of sports facilities, with nothing sacrificed in playing space, spectator seating, concessions or other amenities.

Interior Design Flexibility – The Crenosphere's interior adapts readily to almost any plan. Inside the dome is just space—beautiful, open space. There are no pillars or posts—only unobstructed space. Crenospheres can be single-level or multilevel; they can include mezzanines, hanging press boxes, concession and dining areas, spectator seating and lounges, restrooms and lockers.

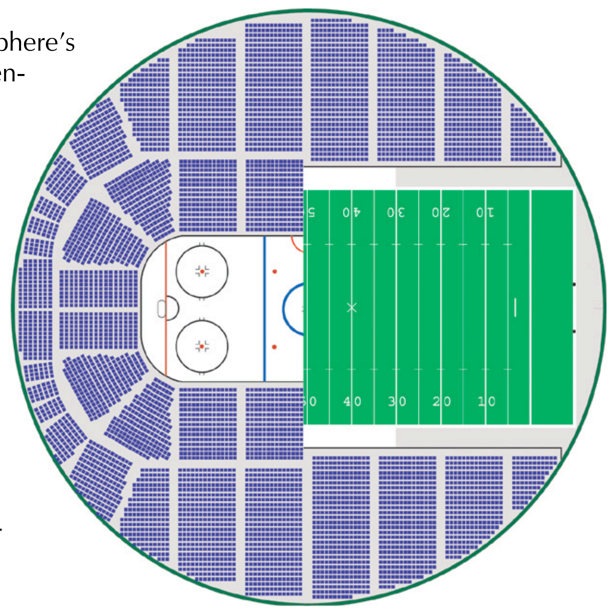
Exterior Design Flexibility – The variety of sizes and shapes make the Crenosphere ideal for football, indoor soccer, baseball, arena football, hockey, basketball, softball, tennis, and more.

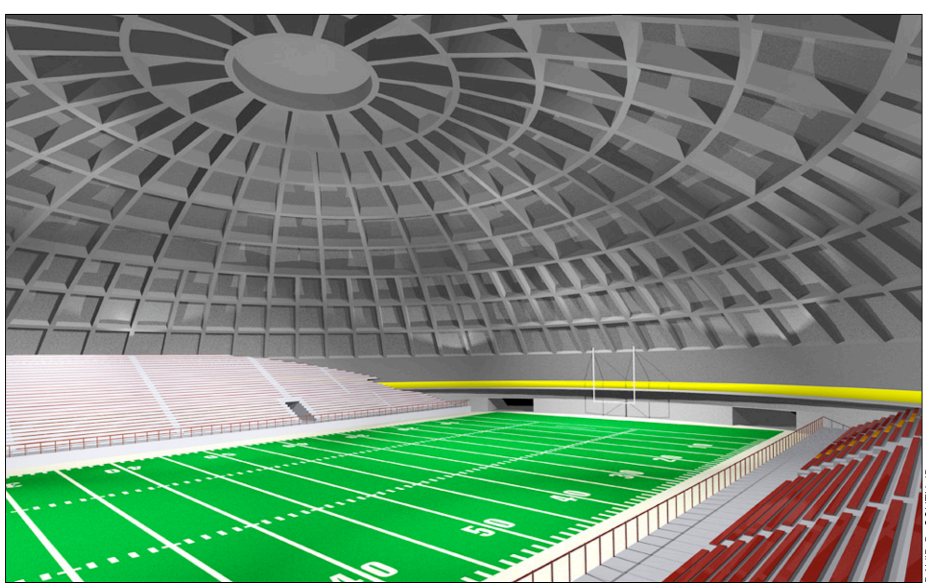
Energy Efficiency – A Crenosphere has superior insulation with an effective R-value of 60. This energy efficiency eliminates sudden changes or peaks in the Crenosphere's interior temperature and greatly reduces heating and cooling costs. What heating or cooling the dome requires can be provided by smaller or fewer units, running for shorter periods.

Cost Efficient Maintenance – The concrete and other materials used in the construction of the Crenosphere make the structure extremely durable and low maintenance.

Durability – The Crenosphere's life-span is measured in centuries, not years. It cannot burn, blow away, or be eaten by bugs. Such durability means less costly insurance premiums, and more importantly, security.

Security – A Crenosphere Dome can instantaneously become a disaster shelter and protect the population of a school or a community from the destructive force of a tornado, hurricane, or earthquake.





DAVID B. SOUTH JR.

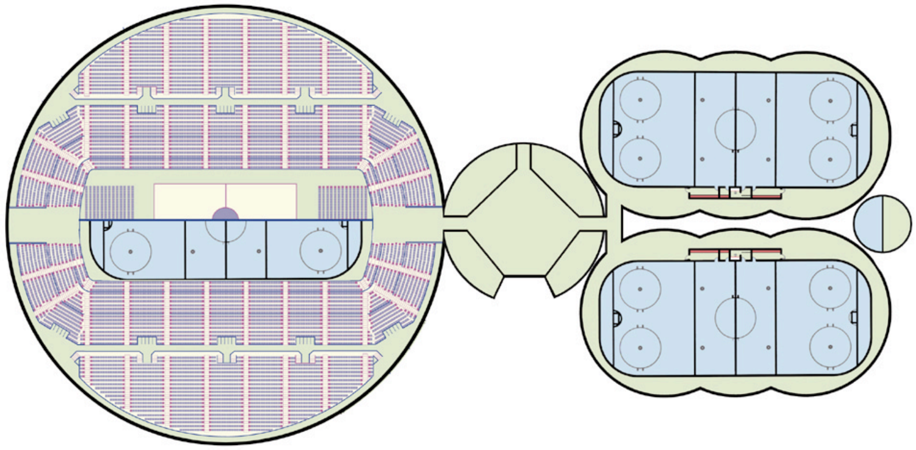
Arenas and Ice Rinks

Facility: Arena and Practice Rinks

Designer: Larry Byrne

Engineer: Dr. Arnold Wilson

Description: Four-dome facility consisting of one 220' diameter dome WPHL standard size arena with 9000 seats, two caterpillars 124' wide by 228.75' long standard size practice rinks, and 100' diameter core facility.



Many communities, colleges, universities, professional teams, and other organizations can now afford a covered, permanent arena. A permanent structure adds diversity and year-round use for any venue.

The initial cost of a Monolithic Dome Arena is substantially less than a conventional arena. This savings is possible because of straight forward design and simple construction.

Advantages

After twenty years of Monolithic Dome construction and analysis, the advantages of this process are proven.

Most of the work is done inside, protected from the weather.

The dome is so strong, many tons of interior structure may be supported directly from it.

Energy use is reduced by over 50 percent, saving money in construction since less heating and cooling equipment is needed, and it saves millions in operating costs over the life of the structure.

The Monolithic Dome meets the most stringent building and fire codes.

Arenas

Inside, a Monolithic Dome easily accommodates skyboxes suspended from its ceiling right over the playing field. Locker and conference rooms, retail shops, restaurants, concessions and other desired amenities fit well around the perimeter of the field below the seating.

Thousands of spectators may attend a variety of games and events. However, ice sports could benefit the most from the Monolithic Dome technology.

Ice Rinks

Ice hockey presents a special problem for many arenas. Hockey currently experiences huge growth throughout the United States thereby increasing demand for ice rinks.

Unlike most field sports, ice sports require a controlled environment, year round, for practice and performance. The problem that many multipurpose arenas face is the conflict between the other venues at the arena and the need to practice on the ice. For example, practice on the ice rink is impossible when the ice covered for a major basketball championship.

Caterpillar Practice Rinks

The best solution is to build practice rinks inside a Monolithic Dome caterpillar. The caterpillar's long, narrow shape easily fits a practice rink, yet its low profile wastes little space. The caterpillar is widest in the center of the rink, allowing a players' area and a few seats.

Each practice rink would be isolated in its own caterpillar. The Monolithic Dome caterpillar is virtually sound proof. There would be absolutely no interference between rinks. If a whistle were blown in one rink, the sound would not affect play in another rink — a major problem in facilities with multiple rinks in the same building.

The Core Building

Tying the facility together would be a medium size dome located between all the buildings. Simple or very elaborate, the core building could contain dressing rooms, a pro shop, referee rooms, offices, restaurants, snack bar, rental shops, and more.

A deluxe core could have an upper deck. Visitors could walk from the upper deck to optional viewing areas suspended over the hockey rinks.

The core dome could also provide easy access to the skyboxes in the Monolithic Dome Arena.

By keeping the hockey rinks cold and the core building warm, the best use of the energy equipment is obtained. In winter the excess heat from the ice compressor can be utilized to heat the center core.

Conclusion

The Monolithic Dome is the ideal choice for a column-free arena and practice facilities. By combining a superior building with an affordable design, many problems with current sports facilities are often eliminated. And energy savings can pay for the whole facility during its lifetime.

RENDERING BY RICK CRANDALL

Swim Center

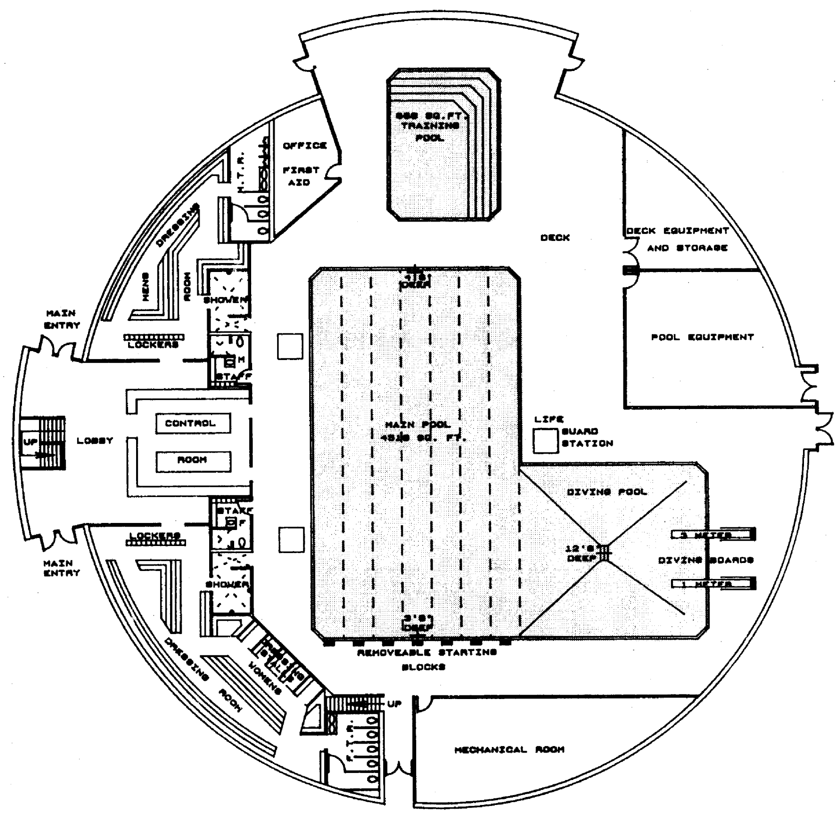
Designer: Larry Byrne

Description: 130 foot diameter dome with 13,270 square feet. The pool is 45' wide and 75' long. A Monolithic Dome could easily be built large enough to enclose an Olympic sized pool with spectator seating. Decking could be added on the second floor of this this design for spectator bleachers.

The Monolithic Dome has some tremendous advantages for swimming facilities. Pools present unique construction problems. The constant humidity in the building affects most building surface materials, causing severe damage. But concrete is waterproof and is only strengthened by humidity.

Another problem for conventional pool buildings: warm water vapor coming in contact with the cooler ceiling makes the ceiling drip cool water. But a Monolithic Dome's ceiling temperature is only slightly affected by outside temperatures. So, even in 98% humidity there is no dripping.

Swimming pools require a large clear span area. The Monolithic Dome is very economical for free span structures.



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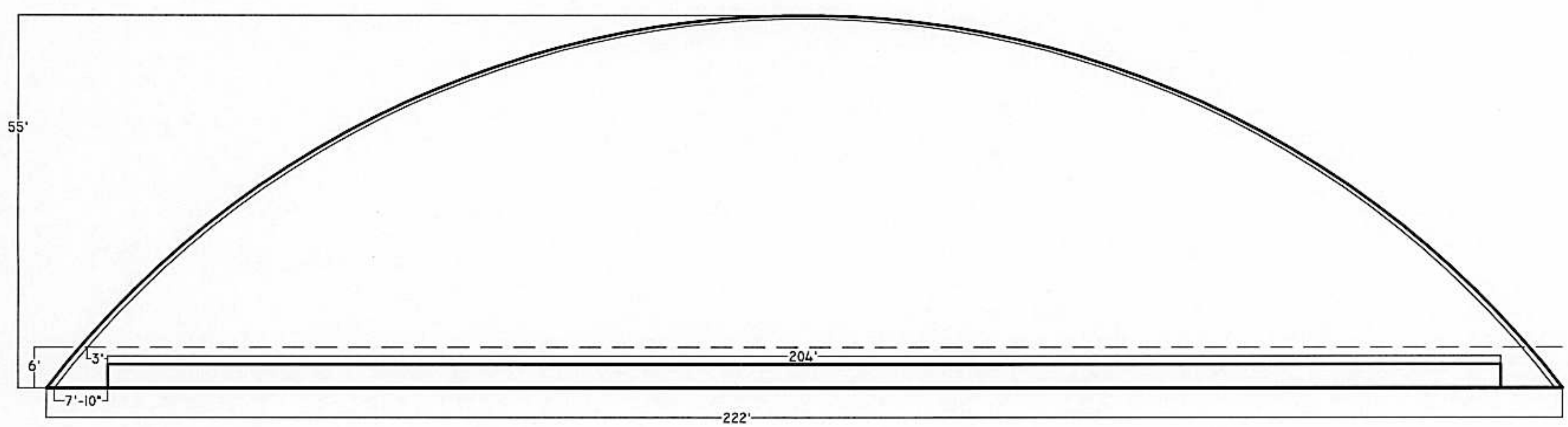
177 Dome Park Place, Italy, TX 76651
972-483-7423
14 January 2004
Single sheet Hockey Dome
SECTION A-A'



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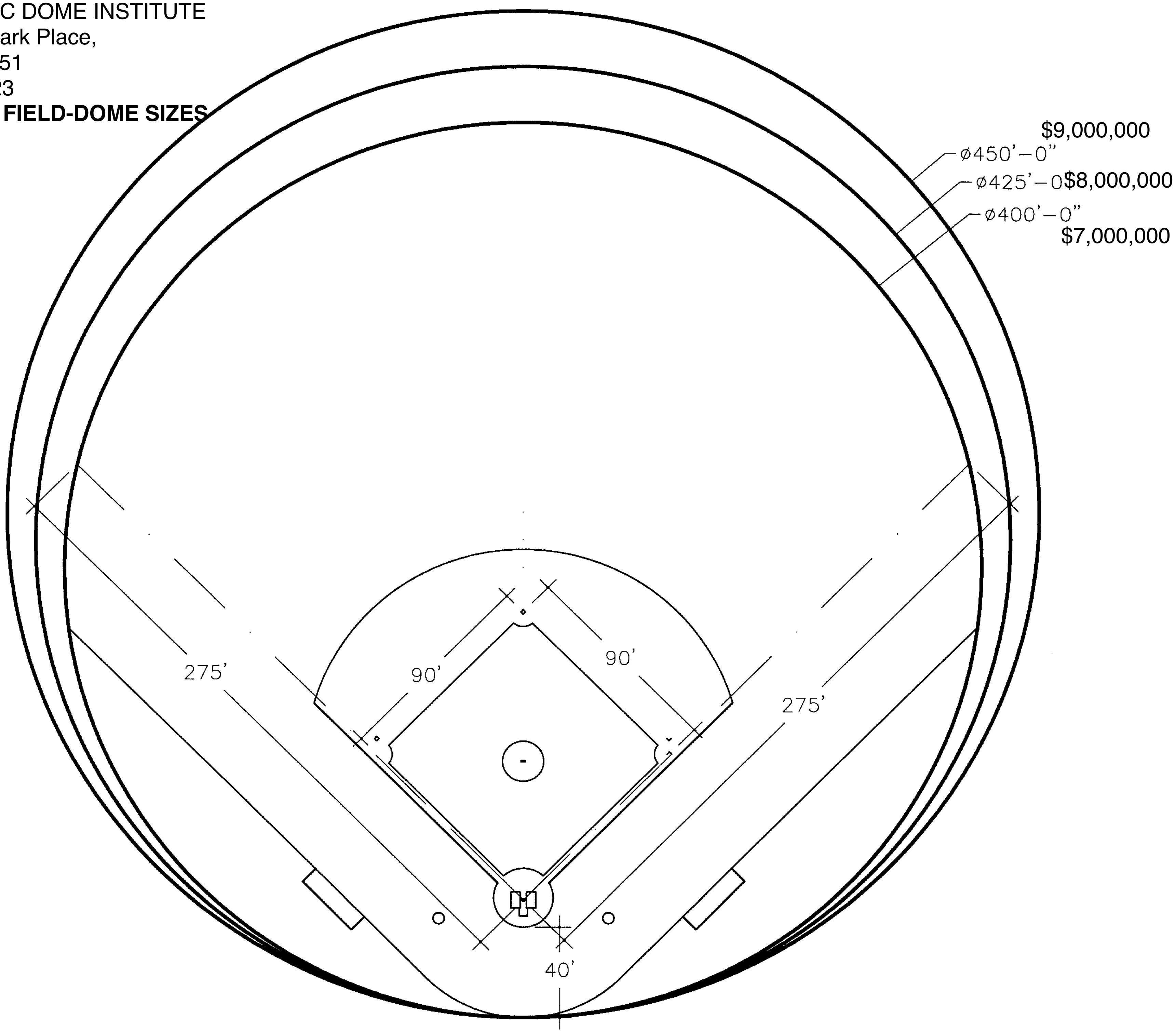
BASEBALL FIELD-DOME SIZES



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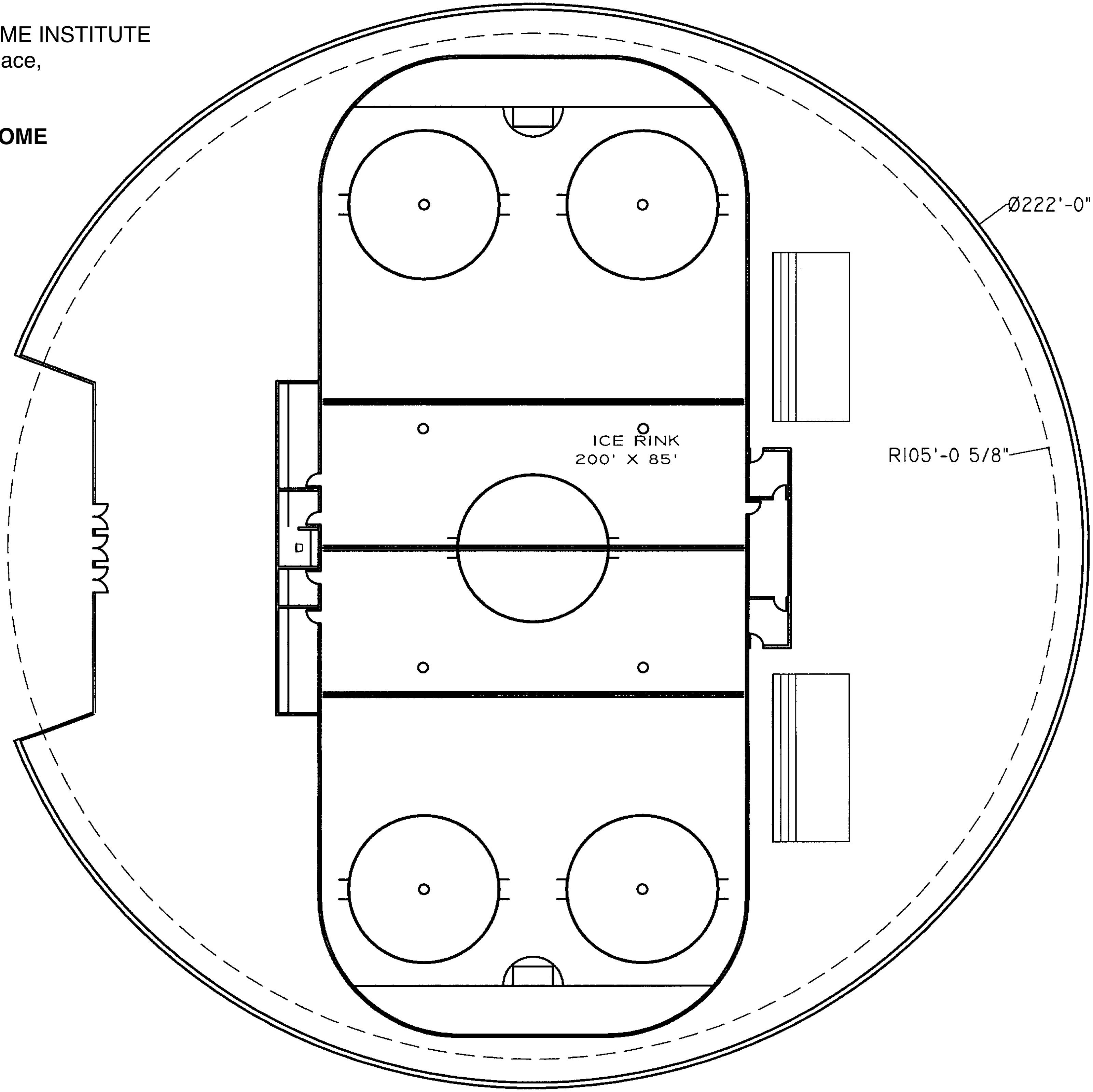
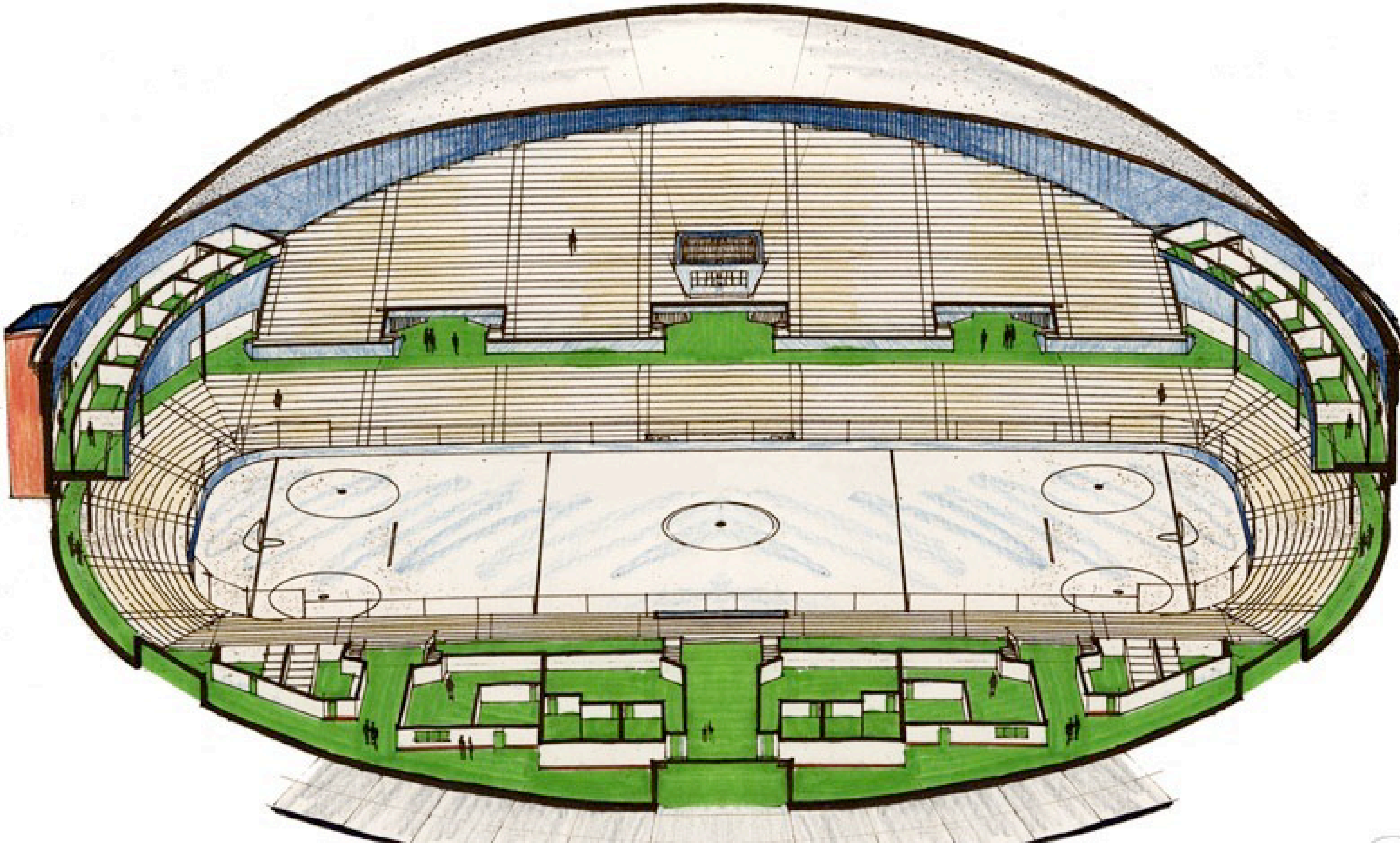
HOCKEY RINK DOME





6002 - Rendering of multi-purpose arena

MONOLITHIC®

June 21, 2007

This is the estimate for rinks in a typical situation. First the prices are figured for Texas. Costs tend to go up a bit in the mid-north, even more in the northeast, and the west coast.

In every case a feasibility study is well worth the cost. It allows the owner to know what they are getting before they commit to construction. It also provides budgets and preliminary plans to help with financing.

Construction estimate based on conceptual design and comparison with other similar completed projects. Budget prices only.

	Square Feet	Shell Only	Finished Low	Finished Medium
Single Practice Rink 124' x 228.75' Caterpillar	24,628	$1,360,000	$2,470,000	
Monolithic Dome Core 80'	5,026	$250,000	$500,000	$650,000
Monolithic Dome Core 120'	11,310	$575,000	$1,150,000	$1,350,000
Monolithic Dome Core 150'	17,671	$885,000	$1,770,000	$2,250,000
Simple Arena 222' x 55.5' (space for 1000 seats)	38,707	$1,451,500	$2,900,000	$3,630,000
Simple Arena 222' x 55.5' on 10' stemwall	38,707	$1,660,000	$3,321,500	$4,200,000
Professional Arena 320 x 115'. (6500 seats) This size needs a feasibility study.	80,425	$4,300,000	$12,000,000	$30,000,000

The estimate does not include land, site, utilities, A&E fees, and parking lot costs.

Monolithic will do a feasibility study for a one-time fee of $7500. The study includes:

- Preliminary Design
- Code Check
- Site Plan
- Budget
- Simple Rendering

June 2007

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177 Dome Park Place • Italy TX 76651 • Tel 972-483-7423 • Fax 972-483-6662

MONOLITHIC®

Commercial Feasibility Study

Schools, Churches, Gymnasiums, Office Buildings, Storages, and more

A Feasibility Study is a preliminary study for a project comparing the Monolithic Dome Process to other building systems. The study defines for the owner the design and intent of the project and provides an estimated budget from the best available information. Monolithic Dome Institute offers to produce a feasibility study for assistance to MDI clients before architectural services are engaged. This study will not provide plans for construction purposes.

MDI will engage qualified design professionals to study the owners program. A budget will be established utilizing the information from the design professionals working with the Monolithic Construction Management personnel.

The Client will provide:

- A program describing rooms, space uses and equipment
- A site plan, survey, and/or plot description of the owners property

MDI will provide:

- A preliminary site schematic developed from information furnished by owner.
- A floor plan to scale showing all described space uses.
- An exterior sketch of proposed front building elevation.
- A factual report and estimate of cost for construction using a square foot method based on recent projects of similar type near the same location if possible.

Optional Services Available at extra cost:

• Space planning consultation	$300.00
• Interior Volume Analysis Studies	Call for Quote
• Dome openings and exterior attachment information	$200.00
• Code compliance and testing information	Call for Quote
• Acoustical Design Studies and Sound System Consultation	$350.00
• Bulk storage layout, sizing and placement of inbound and outbound conveyors	$200.00
• Full color rendering	Call for Quote

With the study report and the budget, the owner can evaluate and decide to proceed with information to be given to a local architect, banker or building official. There is no obligation beyond the study itself. The basic fee is starts at $7,500.00, plus travel expenses, if needed (very large studies may require a larger fee.) Fifty per cent (50%) is due with the order for the study. The balance is due upon completion.

Accepted by: Date __________________

____ ____

Print Name and Title Signature

WWW.MONOLITHIC.COM · MAIL@MONOLITHIC.COM
177 DOME PARK PLACE · ITALY TX 76651 · TEL 972-483-7423 · FAX 972-483-6662

Payson Public Schools Herb Weissenfels, Supt. PO Box 919 Dist office 514 w wade Payson, AZ 85547-0919 928-474-2070 adm 928-472-20-47 fax	**Multipurpose Gymnasium** - The dome features one competition court that splits into two practice courts, as well as four coaches' offices, two sets of boys' and girls' locker rooms and storage space. It also seats 2,400. **Frontier Elementary School** – Three 120' diameter domes. One dome serves as a combination gymnasium and music room. The other two domes each have 10 classrooms along their perimeters, which surround a library and cafeteria.
Whiteriver Unified School District Neal DeWitt, Supt PO Box 190 Whiteriver, AZ 85941-0190 928-338-4842 928-338-51-24 fax	**Cradleboard Elementary School. -** The 34,000 square foot, three dome facility serves 300 students from Kindergarten to grade five.
Cibecue Community School Juan Aragon, Supt PO Box 80068 101 Main St Cibecue, AZ 85911 928-332-2591 928-332-2341 fax	**High School -** A 210 foot diameter dome high school for the Cibecue Community. The design is a split level dome with classrooms and labs on the first floor and a gym and other rooms on the second floor.
Little Singer Community Junior High School Mailing: PO Box AQ, Winslow, AZ 86047 Physical: 6.5 miles S of Birdsprings Chapter on Rte. N-71, Navajo Reservation, AZ Superintendent: Dr. Mark Sorensen 928-526-2950 928-526-8994 fax Site Contact: Lucinda Godinez 928-526-6680	Charter Facility for 7^{th} and 8^{th} grades. Opened 1997. The Multi-Purpose Building has a diameter of 120 feet. Its center is a high school sized basketball court and gymnasium, with bleachers for 300 people. This main floor also accommodates classrooms, community rooms, bathrooms, and offices. On the upper level, a jogging track circles behind the bleachers and above the offices and classrooms.
Tolchi' Koch Charter School, Inc Apache County PO Box 310 Winslow AZ 86047 520-526-2950	**Bird Springs Chapter House** **Leupp Library and Parent Center** located at Leupp Corner

Heber-Overgaard Unified School District Ken VanWinkle, Supt. PO Box 547 3375 Buckskin Canyon Rd Heber, AZ 85928 928-535-4622	**Mountain Meadows Elementary -** They dubbed their smaller dome (80' diameter) the cafetorium because it includes the cafeteria, auditorium and kitchen. The first floor of the larger (160' diameter), two-story dome houses classrooms, a media center, offices, and areas for Special Education, the Preschool, a Nurse's Station and a staff lounge. The second story is for later expansion.
Indian River Community College Pat Ivey 3209 Virginia Ave Fort Pierce, FL 34981 772-462-4787 772-462-4415 fax	**Planetarium** – Planetarium for the science center at the college.
St Martha's Roman Catholic Church Fausto Stampiglia, Father 200 North Orange Ave Sarasota FL 34236 941-366-4210 941-954-84-34 fax	**Bishop Nevins Academy and Dreams are Free** Four domes – The Academy has a diameter of 140 feet and classrooms for students in pre kindergarten through grade eight. Another dome, 124' diameter, with its state-of-the-art kitchen serves as a cafeteria for both schools. Dreams Are Free is a non-graded school with programs for special-needs children, six to fifteen years old, and also functions as a training center for teachers. It's dome is a structure with 11,500 square feet of flexible class space within its 124-foot diameter. A chapel is the central core of the fourth Dome (128' diameter). In addition to the chapel, this Dome has administrative offices, computer labs and a library on its ground floor and classrooms above.
Emmett High School Duane Horning, Principal 601 E 3rd St Emmett, ID 83617 208-365-6323	Built in 1986, this first Monolithic Dome **High School** serves 900 students using two 180 foot diameter Domes to house the classrooms and gymnasium. Three smaller Domes house the woodworking, metal and auto shops.
Park University Dorla Watkins, Vice President 8700 River Park Dr Parksville, MO 64152 913-967-8518x518	**Breckon Sports Events Center** – Twin gymnasiums, each 130' feet in diameter, a performance gym and a practice gym.
Ogemaw Hills Christian School Nancy Perry, Chair 2106 South Gray Rd West Branch, MI 48661 989-345-2084 989-345-2094 fax www.ogemawhills.org	**Kindergarten through 11th grade.**

Grand Meadow School District Bruce Klaehn, Supt PO Box 68 209 1st St NE Grand Meadow, MN 55936 507-754-5310 507-754-5608 fax bklaehn@gm.k12.mn.us	Five Domes that encompass classrooms, cafeteria, auditorium, gymnasium, computer lab and administrative offices. These new structures currently serve 350 students and 30 teachers in **Kindergarten through Grade 12** and include room for an additional 100 students.
Rock Port R-11 Richard Baldwin Supt. 600 Nebraska Street Rock Port, MO 64482 660-744-6294 660-744-5539 fax rbaldwin@rockport.k12.mo.us	**Technology Center** for the school. Its single floor design of 14,500 square feet includes seven labs, classrooms and a library for its 423 students and forty-five teachers.
Pattonsburg School District Ron DeShon, Supt. 504 W 4th St. Pattonsburg, MO 64670 660-367-4397x232 660-367-2111	Four Dome school for **K through 12**. The largest of the domes houses a gymnasium, stage, music, and art areas. The smaller domes hold classrooms, a library, a cafeteria, and offices.
Valley R-6 Schools Steve Yount,supt 1 Viking Dr Caledonia, MO 63631 573-779-3446 supt	**Caledonia Elementary –** two 110 diameter domes. **Multipurpose Gymnasium -** for Valley High School - seats 800
School of Communication Arts Debra Hooper Director 3220 Spring Forest Rd Raleigh, NC 27616 919-981-0972 919-981-0946 fax debra@sca3d.com http://www.sca3d.com/	**Digital Production Campus -** The three domes stand on an 11-acre site. Two of the domes house pie-shaped classrooms,and the third features a 200-foot, high-definition theater, a soundstage, a mixing stage, and an editing and audio suite for the school's digital filmmaking program. A flat-roof traditional building, which will serve as the library and administrative offices, will connect the three domes.
Mountainair School District Guy Seiler, Supt 512 Ross St Mountainair, NM 87036 505-847-2333	**Mountainair High School Gymnasium –** 110' diameter

Texhoma School District Rick Kibbe, Supt PO Box 648 418 Elm St Texhoma, OK 73949 580-423-7433 580-423-7096 rkibbe@texhoma.k12.ok.us	Two Domes, 108' and 66' diameters, house 426 students in grades five through twelve.
North Central Texas College Dr. Ronnie Glasscock, President 1525 W California St Gainesville, TX 76240 817-430-0352 x 230 rglasscock@nctc.edu http://www.nctc.cc.tx.us	**Performing Arts Center -** The 130-foot diameter dome will include a conventional theater space with seating for 400, a proscenium stage, in addition to classrooms, labs, rehearsal rooms, scene shop and other features. Expected to open January 2005.
Italy ISD Mike Clifton, Supt. 300 S College St Italy, TX 76651 972-483-7411 972-483-6152	**Gladiator Coliseum -** Monolithic Dome,two-story,148' diameter as Multipurpose Center,that includes gymnasium with walking track, seating for 1500, auditorium,classrooms for special activities and concrete parking area and drives.
Avalon ISD David Delbosque PO Box 455 104 FM 55 Avalon, TX 76623	**Multipurpose Center -** for 250 students in Pre kindergarten to Grade 12. This Monolithic Dome measures 124'x25' with a total height of 37-feet. It features seating for 720, a full-size basketball court, four locker rooms, a front foyer concession, and bathrooms.
Trinidad ISD Michael Green Supt PO Box 349 203 Eaton Trinidad, TX 75163 903-778-2415 903-778-4120 fax	**Multipurpose Gymnasium and Fieldhouse –** For K through 12. The 130' diameter Dome will seat 800. The 60' diameter fieldhouse by the football field provides restrooms and concessions. Estimated completion November 2004
Centro de la Familia de Utah Rudy Anderson 3780 South West Temple Salt Lake City, UT 84115 801-521-4473 801-521-6242 rebecca@la-familia.org Dome Location – Genola, Utah	A **Head Start Program** for babies (waddlers), toddlers and pre-kindergarten-aged children in Genola, Utah. The facility includes a 101' x 31' central dome featuring classrooms, restrooms, an observation area, nurses station, offices and reception area. A 60' x 23' activity dome features a balcony overlooking the recreational area. The two 30' x 15' domes on 17-foot stemwalls provide a kitchen, cafeteria and resource center.

Building Survivability

The Monolithic Dome is the most disaster resistant building that can be built at a reasonable price without going underground or into a mountain.

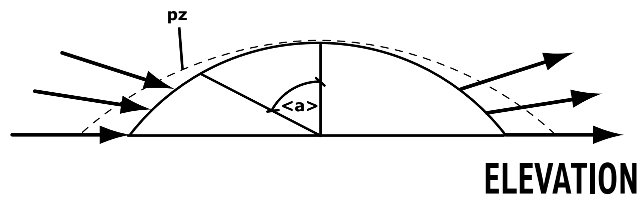
A wind of 70 miles per hour blowing against a 30 foot tall flat walled building in open flat terrain will exert a pressure of 22 pounds per square foot (see sidebars). If the wind speed is increased to 300 miles per hour the pressure is increased to 404 pounds per square foot (psf). Wind speed of 300 MPH is considered maximum for a tornado. It is far greater than that of a hurricane.

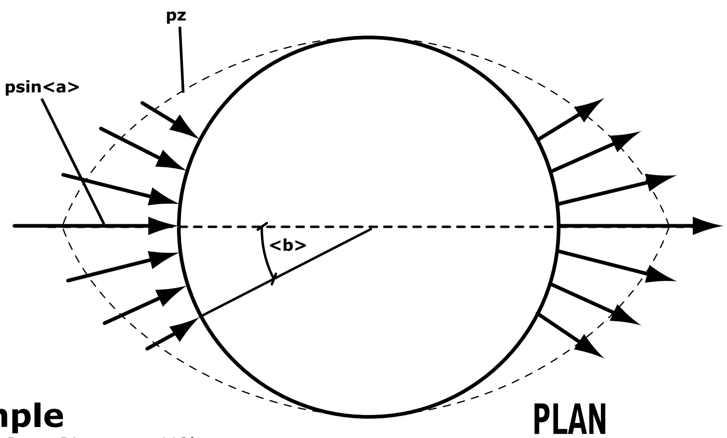
[Cars can be parked on 100 psf. The side pressure on the building could equal the weight of cars piled 4 high. No normal building can withstand that much pressure. Many Monolithic Domes are buried up to 30 feet deep. They must withstand pressures up to 1 ton per square foot (2000 psf)].

Against tornado pressure a Monolithic Dome 100 feet in diameter, 35 feet tall would still have a safety margin of nearly 1½ times its minimum design strength. In other words, the stress created by the 300 mile per hour wind would increase the compressive pressure in the concrete shell to 1,098 psi. The shell is allowed 2,394 psi using design strengths of 4,000 psi.

The fact is the Monolithic Dome is not flat and therefore never could the maximum air pressure against it of 404 pounds per square foot be realized. Neither is the concrete only 4,000 psi. It is always much greater. The margin of safety is

Concrete Dome Seismic Analysis





Example

Dome Diameter = 110’
Height of Dome = 37’
Thickness = 3” @ top and 8” @ bottom
Ref: Billington 1985 Ed., p. 55

pz = pcos<b> sin<a>
p<a> = p<b> = o

Membrane Forces

N<a> = - apk$_1$ cos<b>
N<ab> = - apk$_2$ sin<b>
N<b> = - apk$_3$ cos<b>

Seismic Force (UBC 1985 Edition)

V	= ZSICKW	(Formula for the total design lateral force)
Z	= 1.0	(Zone IV — Seismic Zone Factor)
CS	= 0.14	
I	= 1.5	(Importance Factor = Hospital)
K	= 2.0	(Unusual building such as Dome — very conservative)

Therefore: V = (1.0) (1.5) (0.14) (2.0) W = 0.420W — Note: V = 0.14W for normal shear wall building!

V = (0.420) (100) = 42.0 psf (pounds/square foot) — one square foot of shell 8” thick weighs 100 lbs.

The value of p = V = 42.0 psf.

For demonstration purposes assume p = 60 psf. This represents earthquake forces in excess of the most sever code requirement by a factor of 1.4.

Maximum stress due to N<b> is -64.8 psi; N<a> is -70.6 psi. Maximum bending moment is 909.3 lbs - ft/ft.

For a vertical live load of 40 psf in addition to the dead load of the shell the following stresses and moment are obtained. Maximum stress due to N<a> = -82.5psi; N<b> = -70.7 psi or .146.5 psi. The maximum bending moment is 1,588.0 lbs-ft/ft.

The maximum allowable compressive force in the concrete is: fc = 1.33 (0.45) (4000psi) = -2.394psi. This is many times greater than the -70.6psi needed.

Conclusion

The forces caused by a major earthquake are considerably less than normal provided for when a dome is designed for nominal vertical loads.

probably more like three or four.

The Monolithic Dome at Port Arthur, Texas has now been hit by three hurricanes. A hurricane does not exert enough pressure on a dome to be even noticed. As shown above the dome can very easily withstand the stresses of a tornado.

However, debris carried by a tornado could cut the surface membrane. If the debris contained a large timber or metal object, it might be possible if conditions were just right to put a puncture into the dome. But the puncture would be very local and would certainly never cause serious collapse of the dome. Possibly damage to the doors or windows may occur if there was a rapid decompression caused by the tornado.

For most Monolithic domes the likely disaster will be earthquake. The worst areas in the United States are listed as seismic zone 4. From analysis (see "Concrete Dome Wind Analysis" sidebar) it is easy to see that earthquake forces do not even approach the design strength the Monolithic Dome is built to withstand under normal every day usage. It would take an external force many times as large as the earthquake to approach the design strength of the concrete itself.

Nuclear fallout is another disaster consideration. It is interesting to note that the only structure left standing near ground zero at Hiroshima was the concrete skeleton of a dome. Certainly the Monolithic Dome would be superior to most buildings if a nuclear fallout condition occurred. Rain would tend to wash the radiation off the building much better than conventional buildings.

Generally the Monolithic Dome is quite tall. Radiation strengths are inversely proportional to the square of the distance from the source. The roof of the Monolithic Dome would hold the radiation further from the occupants than many other structures. Also concrete itself is a good absorber of radiation. The concrete Monolithic Dome would greatly reduce the effects of fallout on the occupants.

It is interesting to note that German thin shell structures stood up to allied bombing in the second world war better than most other structures. When a bomb would hit a thin shell it would either bounce off their tough resilient exterior or it would puncture a hole through.

Since there are no single components that carry large loads, there is nothing that can be knocked down like a beam or a column. Therefore repair was a simple patch to cover the hole that was made when the bomb would go through.

"Thin Shell" is the generic name for a Monolithic Dome.

This information was compiled by Doctor Arnold Wilson, a leading engineer in thin shell concrete construction.

Wind Speed	Pressure
70 mph	**22 psf**
100 mph	**50 psf**
150 mph*	**100 psf**
300 mph**	**404 psf**

***Force 5 hurricane (worst)**
**** Force 5 tornado (worst)**

Concrete Dome Wind Analysis

Example 1

Commercial building 30 feet high in exposure C (most severe exposure in open flat terrain). Using design wind pressure from UBC 1985 Edition, section 2311.d, of 70 MPH. V = 300 MPH.

$p = C_e\ C_q\ Q_s\ I$
I = 1.0 (Commercial Building)
Q_s = 13psf (pressure from wind)
C_e = 1.3 (building height 30 ft. - exposure C)
C_q = 1.3 (method 2)

Therefore p = (1.3) (1.3) (1.3psf) (1.0) = 22psf

Example 2

Assume same building and same exposure but with wind speed of 300 mph.

Preference: Finte, Mark, Handbook of Concrete Engineering; Nan Nostrand Reinhold, 1974.

$p = 1/2\ C_s\ C_a\ C_g\ P\ V_h^2\ (H/h)^{2/alpha}$

Assume everything is constant except the wind speed.

$p = C\ V_h^2$ = 22psf for V = 70 mph (example 1).
Therefore $C = (22) / (70)^2 = 0.00449$
Then $p = (0.00449)\ V_h^2$ for V = 300 mph; p = 404psf

The maximum concrete stress in dome 100 feet in diameter by 35 feet high with p = 400psf is 1,098psi compression. From the "Concrete Dome Seismic Analysis" example we see the allowable stress is significantly higher at 2,394 psi.

Conclusion

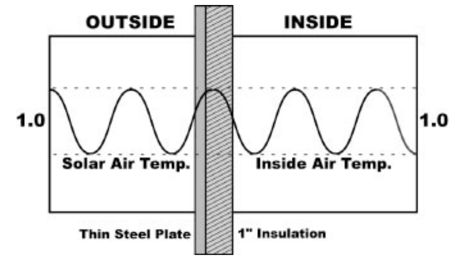
The forces caused by wind and earthquake on a concrete dome generally do not control the design. Domes are very strong and durable and in a realistic situation would probably still be standing when all conventional structures had failed.

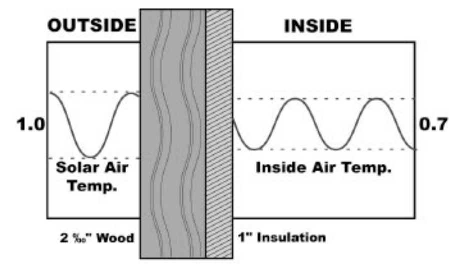
1.4 Optimal Use of Mass and Insulation

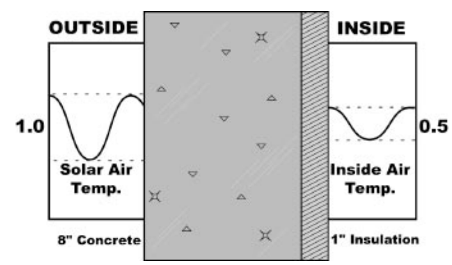
A heavy wall must have two qualities in order to dampen diurnal changes in the exterior environment relatively constant: *heat capacity* — the ability to store heat, and *low heat conductivity* — the ability to resist, or to insulate against heat flow. If one intermittently exposes an adobe brick first to a blow torch and then to cold water (and if each exposure time is relatively short) the temperature of the brick never reaches either extreme, but oscillates somewhere in between. The heat capacity of the brick keeps its temperature from rising rapidly with the small heat addition, or dropping rapidly with the small heat extraction. The brick's insulating quality prevents heat from entering or leaving very rapidly.

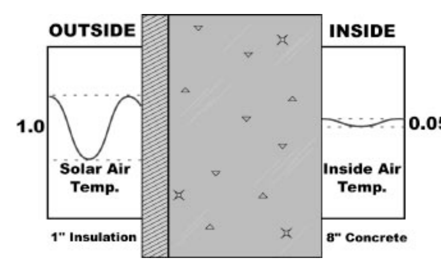
Adobe, however, does not happen to have the optimum combination of heat capacity and insulation. This problem can be resolved by the way the material is used which is as important as what material is used. The most effective way of maximizing the two qualities — eat capacity and insulation — in a building wall is to use two separate materials. Ideally, one would choose a material with little resistance to heat flow. By placing the insulating material next to the external environment, little heat is allowed into or out of the building and with the high heat capacity material next to the inside environment, what heat does enter or leave (primarily through windows and interior heat generation) cannot change the temperature of the heat capacity material rapidly. Thus, little heat is let in or out, and the high capacity material slowly stores heat. The building's thermal mass damps out temperature fluctuations.

Thus a more ideal wall than adobe alone would be one made of externally insulated adobe or externally insulated concrete. This concept of externally insulated, high mass construction is common to all of the passive concepts in this handbook except those using isolated heat storage arrangements such as the rock bed thermosiphon system.









Reprinted from the California Energy Commission "Passive Solar Handbook."

“My Monolithic™ Dome buildings are saving me 75% on heating and cooling bills.”

— Phillip Ricks, Owner, K-P Foods, Inc.

The Monolithic Dome may be the best engineered, best insulated and least expensive permanent building in the world today.

Though only a recent innovation, over 200 Monolithic Domes are in use across the country today. They are being used in every capacity — from warehouses to government offices, from factories to freezers, from retail stores to storage, and many homes.

Monolithic Domes are typically being built for half the cost and in half the time of comparable structures. They are often built in the middle of the winter.

In every size and capacity, owners are reporting significant savings in heating and cooling the Monolithic Dome.

K-P Foods, Inc., manufacturer of a frozen dessert product, uses a 1250 square foot Dome to store its product at -5 degrees (F). Based on refrigeration experts’ opinions, the freezer should be using **four** times the 5 tons of generator power it uses.

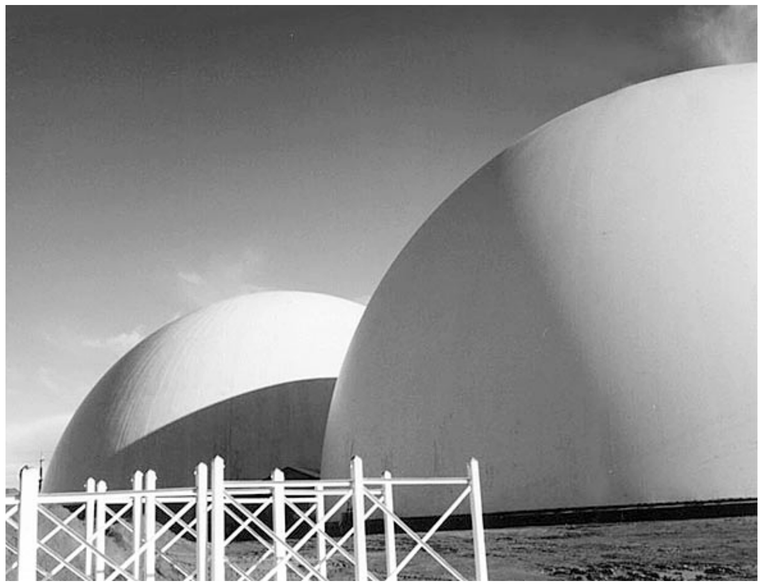
K-P’s manufacturing plant, 6,350 square foot dome, is heated in winter with 120,000 BTUs of power. Experts insist the plant needs **five** times more heating power. K-P owner Phillip Ricks has substantiated his savings by comparing his electric bill with others.

To understand why the Monolithic Dome is so energy efficient, you need to know how it is built.

Construction begins by inflating a fabric form. The inside of this form is sprayed in a continuous sheet with two to five inches of polyurethane foam. A custom-designed network of steel bars is attached to the interior side of the foam and then sprayed with 2 to 6 inches of high-density concrete.

An engineering report: Why the MonolithicDome is so energy efficient:

The massive concrete shell acts as a “heat sink,” storing incoming heat and releasing it slowly to reduce peak loads.



CALAMCO Cold Storage facility. Each Monolithic™ Dome is 230 feet in diameter and can store 13,000 tons of fruit — that’s over 600 semi-truck loads.

Polyurethane foam has the highest insulative value of any building insulation.

Since the insulation is bonded to the **outside** of the concrete, it reduces the amount of heat being transferred into or lost from the concrete to outside conditions, thus increasing the temperature buffering effect of the concrete.

Because the urethane is sprayed in a continuous shell, there are no joints, thus eliminating leaks. The Dome is seamless and nearly air tight.

The Monolithic Dome has many other important advantages, including its great strength, durability, and resistance to fire and corrosion.

Learn more about why so many businesses are choosing the Monolithic Dome. If you’d like, we’ll put you in touch with other Monolithic Dome owners.

With energy and building costs constantly rising, you really deserve to investigate further.

"R" Fairy Tale

By David B. South

The Myth of Insulation's R-value

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email@monolithic.com - www.monolithic.com

"R" Fairy Tale

One of the fairy tales of our time is the "R-value." The "R-value" is touted to the American consumer to the point where it has taken a "chiseled in stone" status. The saddest part of the fairy tale is that the R-value by itself is almost a worthless number.

It is impossible to define an insulation with a single number. It is imperative we know more than a single "R" number. So why do we allow the R-value fairy tale to be perpetuated? I don't know. I don't know if anybody knows. It obviously favors fiber insulation. Consider the R-value of an insulation after it has been submersed in water or with a 20 mile per hour wind blowing through it. Obviously the R-value of fiber insulations would go to zero. Under the same conditions, the solid insulations would be largely unaffected. Again R-value numbers are "funny" numbers. They are meaningless unless we know other characteristics.

None of us would ever buy a piece of property if we knew only one dimension. Suppose someone offered a property for $10,000 dollars and told you it was a seven. You would instantly wonder if that meant seven acres, seven square feet, seven miles square, or what. You would want to know where it was — in a swamp, on a mountain, in downtown Dallas. In other words, one number cannot accurately describe anything. The use of an R-value alone is absolutely ridiculous. Yet we have Code bodies mandating R-values of 20's or 30's or 40's. A fiber insulation having an R-value of 25 placed in a house not properly sealed will allow the wind to blow through it as if there were no insulation. Maybe the R-value is accurate in the tested material in the lab, but it is not even remotely part of the real world. We must start asking for some additional dimensions to our insulation. We need to know it's resistance to air penetration, to free water, and to vapor drive. What is the R-value after it is subjected to real world conditions?

The R-value is a fictitious number supposed to indicate a material's ability to resist heat loss. It is derived by taking the "k" value of a product and dividing it into the number one. The "k" value is the actual measurement of heat transferred through a specific material.

> **"Rigid urethane foam has been called "super-insulation" because, inch for inch, it provides almost one-and- a-half to three times the insulation value of other insulating materials.**
>
> **Highly resistant to water and water vapor, it retains its insulation effectiveness indefinitely."**
>
> *"Section 1", Urethane in Building, Mobay Chemical Corporation, Pittsburgh-, PA*

The Test used to determine the "R" value:

The test used to produce the "k" value is an ASTM test. This ASTM test was designed by a committee to give us measurement values that hopefully would be meaningful. A major part of the problem lies in the design of the test. The test favors the fiber insulations — fiberglass, rock wool, and cellulose fiber. Very little input went into the test for the solid insulations, such as foam glass, cork, expanded polystyrene or urethane foam.

The test does not account for air movement (wind) or any amount of moisture (water vapor). In other words, the test used to create the R-value is a test in non-real-world conditions. For instance, fiberglass is generally assigned an R-value of approximately 3.5. It will only achieve that R-value if tested in an absolute zero wind and zero moisture environment. Zero wind and zero moisture are not real-world. Our houses leak air, all our buildings leak air, and they often leak water. Water vapor from the atmosphere, showers, cooking, breathing, etc. constantly moves back and forth through the walls and ceilings. If an attic is not properly ventilated, the water vapor from inside a house will very quickly semi-saturate the insulation above the ceilings. Even small amounts of moisture will cause a dramatic drop in fiber insulation's R-value — as much as 50 percent or more.

Vapor Barriers:

We are told, with very good reason, that insulation should have a vapor barrier on the warm side. Which is the warm side of the wall of a house? Obviously, it changes from summer to winter — even from day to night. If it is 20 F below zero outside, the inside of an occupied house is certainly the warm side. During the summer months, when the sun is shining, very obviously the warm side is the outside. Sometimes the novice will try to put vapor barriers on both sides of the insulation. Vapor barriers on both sides of fiber insulation generally prove to be disastrous. It seems the vapor barriers will stop most of the moisture but not all. Small amounts of moisture will move into the fiber insulation between the two vapor barriers and be trapped. It will accumulate as the temperature swings back and forth. This accumulation can become a huge problem. We have re-insulated a number of potato storages that originally were insulated with fiberglass having a vapor barrier on both sides. Within a year or two the insulation would completely fail to insulate. The moisture would get trapped between the vapor barriers and saturate the fiberglass insulation to the point of holding buckets of water. Fiber insulation needs ventilation on one side; therefore, the vapor barrier should go on the side where it will do the most good.

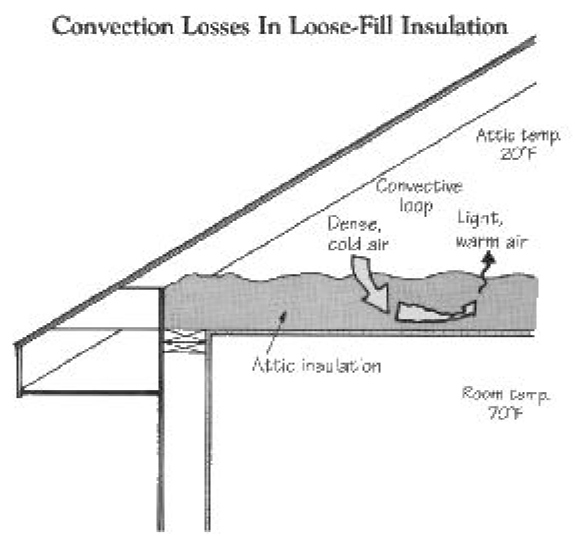
We understand air penetration through the wall of the house. In some homes when the wind blows, we often can feel it. But what most people, including many engineers, do not realize is that there are very serious convection currents that occur within the fiber insulations. These convection currents rotate vast amounts of air. The air currents are not fast enough to feel or even measure with any but the most sensitive instruments. Nevertheless, the air is constantly carrying heat from the underside of the fiber pile to the top side, letting it escape. If we seal off the air movement, we generally seal in water vapor. The additional water often will condense (this now becomes a source of water for rotting of the structure). The water, as a vapor or condensation, will seriously decrease the insulation value — the R-value. The only way to deal with a fiber insulation is to ventilate. But to ventilate means moving air which also decreases the R-value.

Air Penetration:

What is the R-value of a furnace filter? The filter medium for most furnace filters is fiberglass — the same spun fiberglass used as insulation. Fiberglass is used for an air filter because it has less impedance to the air flow, and it is cheap. In other words, the air flows through it very readily. It is ironic how we wrap our house in a furnace filter that will strain the bugs out of the wind as it blows through the house. There are tremendous air currents that blow through the walls of a typical home. As a demonstration, hold a lit candle near an electrical outlet on an outside wall when the wind is blowing.

The average home with all its doors and windows closed has a combination of air leaks equal to the size of an open door. Even if we do a perfect job of installing the fiber insulation in our house and bring the air infiltration very close to zero from one side of the wall to the other, we still do not stop the air from moving through the insulation itself vertically both in the ceiling and the walls.

The best known solid insulation is expanded polystyrene. Other solid insulations include cork, foam glass and



At very cold temperatures, when the temperature difference across the attic insulation reaches a certain critical point, convection within the insulation can reduce R-value.

Nisson, J.D. Ned, JLC, "Attic Insulation Problems In Cold Climates" March 1992, pp. 42-43

polyisocyanate or polyisocyanurate board stock. The later two being variation of urethane foam. Each of these insulations are ideally suited for many uses. Foam glass has been used for years on hot and cold tanks, especially in places where vapor drive is a problem. Cork is of course a very old standby often used in freezer applications. EPS or expanded polystyrene is seemingly used everywhere from throw away drinking cups and food containers to perimeter foundation insulation, masonry insulations, etc. Urethane board stock is becoming the standard for roof insulation, especially for hot mopped roofs. It is also widely used for exterior sheathing on many of the new houses. The R-value of the urethane board stock is of course better than any of the other solid insulations. All of the solid insulations will perform far better than fiber insulations whenever there is wind or moisture involved.

Most of the solid insulations are placed as sheets or board stock. They suffer from one very common problem. They generally don't fit tight enough to prevent air infiltration. It matters not how thick these board stocks are, if the wind gets behind it. We see this often in masonry construction where board stock is used between a brick and a block wall. Unless the board stock is actually physically glued to the block wall air will infiltrate behind it. In this case it is virtually worthless as the air flows through the weep holes in the brick and around the insulation rendering it virtually useless. Great care must be exercised in placing the solid insulations. The brick ties need to be fitted at the joints and then sealed to prevent air flow behind the insulation.

The only commonly used solid insulation that absolutely protects itself from air infiltration is the spray-in-place polyurethane. When it is properly placed between two studs or against the concrete block wall or wherever, the bonding of the spray plus the expansion of the material in place will effect a total seal. This total seal is almost impossible to overestimate. In my opinion most of the heat loss in the walls of the home have to do with the seal rather than the insulation. For physical reasons, heat does not conduct horizontally nearly as well as it does vertically. Therefore, if there were no insulation in the walls of the homes, but an absolute airtight seal, there would not necessarily be a huge difference in the heat loss. This would not be the case if the insulation was missing from the ceiling. Air infiltration can most effectively be stopped with spray-in-place polyurethane. It is the only material (properly applied) that will fill in the corners, the cripples, the double studs, bottom plates, top plates, etc. The R-value of a material is of no interest or consequence if air can get past it.

Anecdotes:

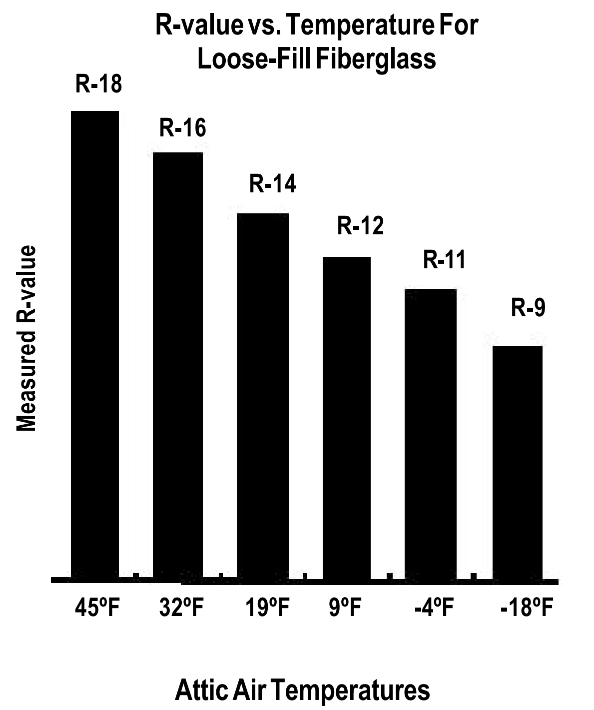
During the 1970s my firm insulated a bunch of new homes in the Snake River Valley of Idaho with 1.25 inches of spray in place polyurethane foam in the walls. In 1970 the popular number for the R-value of one inch of urethane foam was 9.09 per inch. Using this value, we were putting an R of 1.25 x 9.09 = 11.36 in the walls. This was much less than the R = 16 claimed by the fiberglass insulators. Today, using the charts from an ASHRAE book, we would only be able to claim an R-value for the 1.25 inches of 7.5 to 9. Neither of these numbers make for a very big R-value. The reality is that the people for whom we insulated their homes invariably would thank us for the savings in their heat bills. They would tell us their heating bill was half of their neighbor's. They felt as if they saved the cost of the polyurethane in one, or at most two, years. This is anecdotal evidence, I know, but anecdotal evidence is also compelling and very real in our world. Most of these customers were savvy people. They would not have paid the extra to get the urethane insulation if it had not been better.

About mid 1975 I received a call from a division manager of one of the major fiberglass insulation manufacturers. The caller asked, "I understand that you are spraying polyurethane in the walls of homes?"

I told him that was true. He was calling because we were cutting into the fiberglass insulation sales in our area. He asked, "How can you do it?"

I knew what he meant. He wanted to know how I could look somebody in the eye and sell them a more expensive insulation than the cheap old fiberglass. I told him the way I did it is with a spray gun. Of course, that wasn't the answer he wanted. He wanted to know how I could not feel guilty. I told him of insulating one of two nearly identical houses built side by side. We insulated the walls with 1.25 inches of urethane. The other house was insulated with full thick fiberglass batts put in place by a reputable installer. Not only did we use only 1.25 inches of urethane as the total wall insulation, but we had the builder leave off the insulated

"There is a problem with loose-fill fiberglass attic insulation in cold climates. It appears that, as attic temperature drops below a certain point, air begins to circulate into and within the insulation, forming "convective loops" that increase heat loss and decrease the effective R-value. At very cold temperatures (-20°F), the R-value may decrease by up to 50%."



In full-scale attic tests at Oak Ridge national Laboratory, the R-value of 6 inches of cubed loose-fill attic insulation progressively fell as the attic air temperature dropped. At -18° F, the R-value measured only R-9. The problem seems to occur with any low-density, loose-fill fibrous insulation.

Nisson, J.D. Ned, JLC, "Attic Insulation Problems In Cold Climates" March 1992, pp. 42-43

sheathing. At the end of the first winter, the urethane insulated home had a heating bill half of their neighbor's. I know that is not terribly scientific, but it is very real. I am not sure he was convinced, but it should be noted that same company jumped into the urethane foam supply business the next year.

One and a quarter inch of polyurethane sprayed properly in the wall of a house will prevent more heat loss than all the fiber insulation that can be crammed in the walls — even up to an eight inch thickness. Not only does it provide better insulation, but it provides significant additional strength to the house.

One of my early clients was Brent. I had insulated several potato storages for Brent. He knew what spray-in-place urethane insulation could do. When he decided to build his new, very large, very fancy new home, he asked me to come insulate it. The builder pitched a fit. He "didn't need any of that spray-in-place urethane in his buildings. He made his buildings tight, and fiberglass was just as good."

Brent explained to the builder, "I know who is going to insulate the building. It is not as definite as to who is going to be the contractor. You can make up your mind. We are going to have the urethane insulation and you build the building, or we are going to have the urethane insulation, and I will have some one else build the building." It didn't take the contractor long to decide he wanted to use urethane insulation.

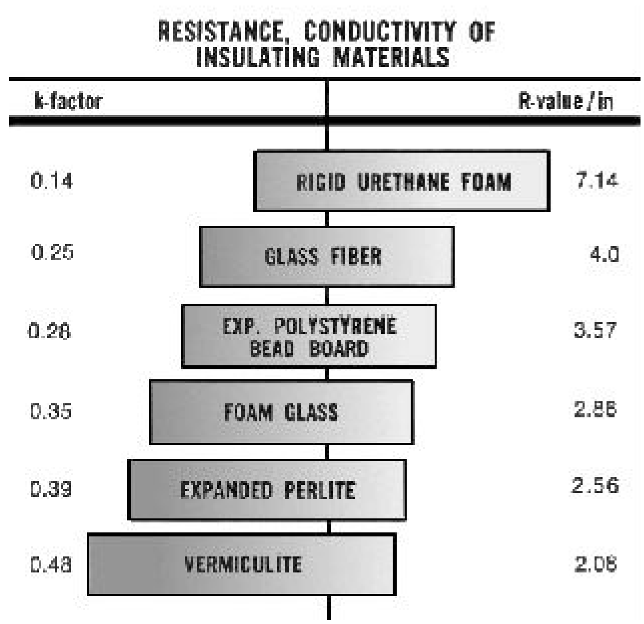
It was amazing to me how it worked out. We sprayed a lot of foam in Brent's house, and it cost him quite a bit of money because it was such a large home. Always after when I would meet him, he would tell me his heat bill was less than any of his rent houses or homes of anybody else he knew. And his home was two or three times larger. Also, the builder started having me insulate most of his new custom built houses. He told me he would explain to his clients the best insulation was the spray in place urethane. It would cost a little more, but it was by far the best. Most of the owners opted for the urethane. Never have I had a customer tell me that he did not save money by using the urethane spray-in-place insulation. You can spend all the time you want with R-values and "k" factors, and "prove" on paper there is no way the urethane can do the insulation job that the fiberglass will. In the real world, I can assure anyone there is no way fiber insulation can be as effective as spray-in-place urethane — not even close.

R-value tables are truly part of the "Fairy Tale." They show the solid and the fiber insulations side by side, implying they can be compared. The fact is, without taking installation conditions into account, comparisons are meaningless. Spray-in-place urethane foam provides its own vapor barrier, water barrier, and wind barrier. None of the other insulations are as effective without special care taken at installation. The fiber insulations must be protected from wind, water and water vapor. Again the tables need a second table to state installation conditions.

Other Anecdotes:

Meadow Gold Company was going to build a freezer in Idaho Falls, Idaho. Chet, the plant manager, was a good friend of the local Butler dealer. The local Butler dealer and I had become good friends. A Butler building does not lend itself very well to a freezer if you are going to insulate the freezer with expanded polystyrene. So the three of us got together and planned a freezer that would accommodate the needs of Meadow Gold yet be built of a Butler building and be properly insulated. This was in my first year of spraying polyurethane foam, and at that time I believed all the literature and knew what we were doing was going to be just right. It turned out even better. The then current R-value table showed one inch of urethane equal to 2.5 inches of expanded polystyrene. So, I suggested we spray the metal building with four inches of urethane to replace the 10 inches of expanded polystyrene normally used by Meadow Gold for freezers.

I sprayed under the slab with four inches, the walls with four inches, and the underside of the roof with five inches of urethane (the fifth inch was added as a safety margin). Chet, the plant manager, was pretty worried because he stuck his neck out going with this non-traditional insulation and the non-traditional building for Meadow Gold Company. Well, the building progressed on schedule, but the equipment to cool the building did not arrive on time. By summer only one of the two refrigeration compressors had arrived. Two compressors were needed (per the Meadow Gold engineers) to handle needs of the building based on using 10 inches of expanded polystyrene.



With the lowest k-factor and the highest R-value, urethane foam can provide more thermal resistance with less material than any other insulation.

Chet considered one alternative to his predicament was to turn one of the older freezers that had been used as a cooler back into a freezer. Then maybe he could make a cooler out of the new building with just the one compressor. It was not a satisfactory arrangement, but it maybe could work. The other thing Chet kept telling us was that he would know as soon as he turned on the freezer equipment whether or not the building would work. When I pressed him, he said that normally it takes five days to bring a freezer down to 10 F below zero — needed for ice cream. When he turned on the new freezer, with only the one compressor, the temperature dropped to 18F degrees below zero by the second morning. They had their freezer. It ran the entire summer using only the single compressor.

Urethane Conserves Energy

Excellent thermal resistance is the primary performance benefit of urethane foam insulation, but it is not the only one. Urethane also has these advantages as a construction material:

a) Its closed cell structure makes urethane most effective initially and in the long run.
b) When protected by skins or other covering, urethane will not absorb water. Consequently the x-factor (thermal conductivity) is virtually constant.
c) Sprayed-on foam has the advantage of no seams or joints.
d) Urethane's thermal resistance means that only one thickness of material is need for most jobs.
e) It has a low moisture permeability (1-3 perms).

Where circumstances demand thinner walls or roofs, urethane — with its superior insulating capability — makes it possible to reduce the thickness of the insulation component with no loss of thermal resistance. Or the thermal resistance of an assembly can be increased without enlarging the size of the member. Urethane helps to offset the design restrictions imposed by the fact that most building materials are constant in thickness and weight.

"Urethane Foam as an Energy Conserver", How to Conserve Energy: in commercial, institutional and industrial construction, Mobay Chemical Corp. Pittsburgh, PA: 1975, p 3

A few weeks after start up of the freezer, I was visited by a Meadow Gold engineer from Chicago. He wanted to know exactly what we had done to insulate the freezer. One compressor should not be able to hold the temperature as it was doing. I explained to him exactly what we had done. He seemed satisfied and he left. A few weeks later he showed up again with his boss. We went to the plant and verified with an ice pick the thickness of the foam. It was indeed four inches in the walls and five inches in the ceiling. Here again they reiterated that the building should not be operating as it was. What they were telling me was that even though I had used one inch of urethane to replace 2.5 inches of expanded polystyrene, the building was still requiring only 50 percent of the normal compressor power for cooling. As you can imagine, the experience made me a lot more bold, and I used the information to sell more freezer insulation jobs.

One of our largest freezer insulation projects was a sixty thousand square foot freezer at Clearfield, Utah. I was able to talk the general contractor into letting us insulate with spray-in-place polyurethane foam the brand-new all-concrete freezer he was building. This building was the 12th in a chain of freezers. My friend Bob, the contractor, had taken it upon himself to make the switch from the ten inches of expanded polystyrene to four inches of urethane with a fifth inch on the roof. The building was built with tilt up concrete insulated on the interior side of the concrete with spray-in-place urethane. We then sprayed on a three-fourths of an inch thick layer of plaster as the thermal barrier. Over the pre-stressed concrete roof panels, we put five inches of spray in place urethane and then covered it with hot tar and rock. (This is an old CPR-specification).

I was on the job the last day. As we finished up the owner showed up. He had expected to see ten inches of expanded polystyrene, and here was four inches of urethane. I told him he would like the four inches of urethane as it would be even better than the expanded polystyrene, based on my previous experience. He told me he was sicker than a dog because he felt like there was no way that could be true. It was too late for him to do anything about it. If he could have, he would have changed the contract instantly, but he was stuck and felt stuck.

They had 12 other similar size freezers, except the others were insulated with expanded polystyrene. The normal way of operating them was to use three large compressor assemblies. Two of the compressors would be needed all summer to keep the building cold, and the third one would be a standby unit, in case one of the other two had problems.

About a year later, I received a phone call from one of the managers. He asked me if I had time to insulate another 60,000 square foot freezer in Clearfield, Utah. I assured him we had the time, the inclination, and the excitement to do it, but I thought the owner wanted nothing to do with urethane foam insulation. The manager explained to me that not only had the Clearfield freezer operated better than any other freezer in their line, it had operated for less than half the costs of any others. They were adding another 60,000 square feet without adding more compressors. The compressor power available to them because of the urethane insulation efficiency allowed them to do it. The building had run very nicely through the hot part of the summer with just one compressor. Now they would be able to run two buildings off of two compressors and still have a spare.

Again, this is anecdotal evidence, but let me assure you that you will get the same results if you do the same thing as we have. I have insulated too many buildings now that I know that this will happen in every case. Never can you use an R-value from a fiber insulation and compare it to the R-value of a foam insulation. Nor can you use the R-value of a foam insulation if it is in sheet form and compare it to the R-value of spray-in-place foam insulation. Spray-in-place polyurethane is an absolute minimum of three to ten times as effective as any other insulation available today.

During the late 1970s, the FTC went after the urethane foam suppliers for misleading advertising especially with regard to fire claims. A consent decree followed. It destroyed

Spray application of urethane foam is fast and efficient. Large wall areas can be covered in minutes. Urethane foam seals wall blocks and around furring to provide seamless, uniform insulated surface.

a tremendous amount of confidence in the use of urethane. Up to that point, Commonwealth Edison would give Gold Medallion approval for homes insulated with 1.25 inches of spray-in-place urethane in the side walls of masonry constructed homes. True, that was anecdotal evidence, but also true, it worked. Much work was done in the early 1970s using a 1.25 inches urethane as a replacement for wall insulation in a home. Not only did it replace the wall insulation, it also replaced the exterior sheathing. Buildings are stronger and better insulated when sprayed with the 1.25 inches of urethane.

Understanding the two purposes of insulation gives a standard to measure the insulations:

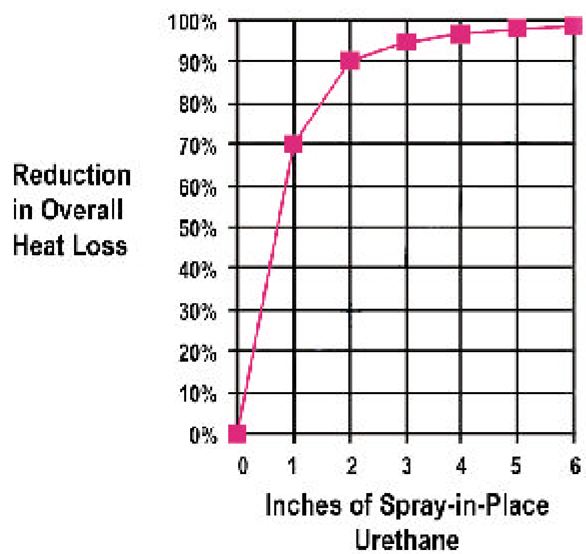
1) Heat loss

There is a little understood part about insulation that needs to be covered. There is a substantial difference between insulation for temperature control and insulation for heat loss control. For instance, the graph shows the heat loss control of the spray-in-place urethane foam insulation. Any insulation will have a similar graph but with thicker amounts of insulation. This graph points out that more insulation is not necessarily cost effective. There is a point where more insulation is pointless from a total heat loss perspective.

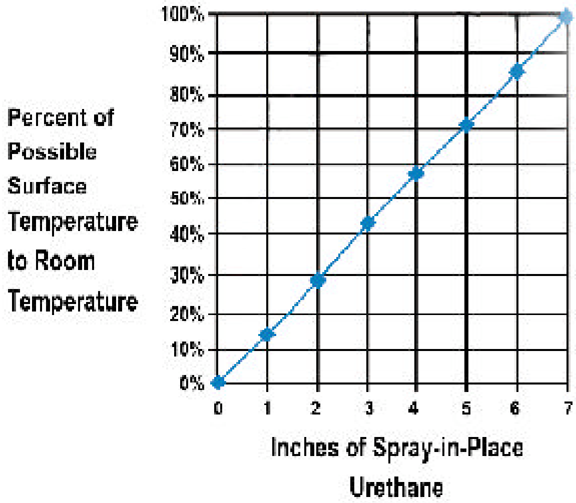
The graph shows that 70% of heat loss from conductance is stopped by a 1 inch thickness of spray-in-place urethane foam. (remember we are going to stop nearly 100% of the heat loss from air infiltration with the first one-fourth of an inch of urethane foam). The second inch of spray-in-place urethane stops about 90% of the heat loss and the third inch 95% and so forth.

Thermal Diffusivity — Heat Sinks:

It should be noted here that when the urethane is used on the exterior of a heat sink, such as concrete, the actual effective R-value is approximately doubled. This is why with the Monolithic Dome, we are able to calculate effective R-values in excess of 60. A heat sink is any substance capable of storing large amounts of heat. Most commonly we think of concrete, brick, water, adobe and earth as heat sink materials used in building. The property of a heat sink to act as an insulation is called thermal diffusivity. The simple explanation for the way it works is: As the temperature of the atmosphere cycles from cold to hot to cold to hot the heat sink absorbs or gives up heat. But because the heat sink can absorb so much heat it never catches up with the full range of the cycle. Therefore the temperature of the heat sink tends to average. Large heat sinks will average over many days, weeks or even months. An example is the adobe hacienda with its 2 to 6 foot thick walls. By the time



This graph illustrates the reduction in heat loss from a building when it is insulated with various thicknesses of spray-in-place urethane foam. Note: the insulation benefit tops off very quickly above three inches. The graph is not exact, but it shows in general what happens as additional insulation is added to the surface temperature. In other words, by super-insulating, the surface temperature of the inside of the exterior walls comes very close to the room temperature. This prevents the condensation, which prevents the growth of mold.



Factors such as ambient air temperature, wind, size of structure, and most importantly, the heat sink available to the structure, may influence the actual heat loss. Other types of insulation will have similar graphs, they just will not be quite as dramatic.

the adobe walls begin to absorb the daytime heat it is night time and the same heat then escapes into the cooler night. Therefore the temperature would average. Because the mass of the adobe is so large the temperature averages over periods of months. Adobe acts as an insulation even though adobe has a minimal "R" value.

You can see from the graph that urethane thicknesses beyond four or five inches is practically immaterial. We use three inches for most of our construction. Two inches will do a very superior job. We have insulated many metal buildings with one inch of urethane and the drop in heat loss is absolutely dramatic. Obviously the first quarter inch takes care of the wind blowing through the cracks (It usually takes an inch to be sure the cracks are all filled). The balance of the inch adds the thermal protection.

2) Surface temperatures control:

Surface temperature control is the second reason for insulation. In many cases it is the most important reason for the insulation. I noticed this phenomena first while insulating potato storages. We had various customers ask us to insulate the buildings anywhere from two to five inches of urethane. The building insulated with two inches would hold the temperatures of the potatoes properly, just as well as the building insulated with five inches. The difference came in the condensation. Potato storages are kept up at very high humidity levels. The buildings with the two inches of urethane would have far more condensation than those with the five inches.

An engineer from the Upjohn company explained this to me. He drew for me a graph as shown here. It shows that thicker insulation is absolutely necessary to maintain higher interior surface temperatures. One and a half inches of urethane on the walls and ceiling of a potato storage would control the heat loss from the building, but it took a minimum of three inches of urethane to control the interior surface temperature. Four inches was even better. With five inches did difference is practically negligible. The only place where we have felt the need for five inches of urethane was insulating the roof or ceiling of a sub-zero freezer.

Underground housing — surface temperature control vs. heat loss control

Most of the underground housing is in trouble from mold and mildew growth. The cause is not enough insulation to control interior surface temperatures. Rarely is there a problem with total heat loss. Water vapor condenses on the surface allowing mold to grow. Mold makes people sick. The only solution is lots of insulation for temperature control and ignore total heat loss as it will not be a factor.

My experience is that R-value tables can be used as indicators. They need modifications to make them equal to real world conditions. There needs to be allowances made. They must show equivalents. These equivalents will be more like one inch of spray-in-place urethane equal to four inches of fiberglass in a normal installation. Footnotes to the table will need to define degradation of insulations in real world conditions. Only then will the "R-value" Fairy Tale become a real world success story. m