OBC *Northwest, Inc.*

Nursery & Greenhouse Supplies

WINTER FARMING SERIES

"Production"

OBC Northwest

Cold Frames and Greenhouses

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<u>FRAME MATERIALS</u> - Steel, aluminum, wood, pvc, other such as concrete, block, combinations

Objective – minimize frame member size, maximize structure size and be herculean strong, last forever!

Steel – durable, strong, probably best for dollar and return

Aluminum – used frequently although more expensive than steel. Often used where weight vs strength is consideration. There are all aluminum frame greenhouses, but more typical are steel aluminum combinations.

Wood – less costly, can be toxic (PressTreat, cresosote), not as strong, more members per given area; breaks down and supports algae, fungus.

PVC – weak, incompatible with many coverings

Other materials – are they economic, and meet the basic objective?

FRAME MATERIALS SHAPE – round, oval, square, rollform, rectangle, other.

Round is very common and is naturally a strong shape – has been referred to as the strongest natural shape. Easy to work, bends well, can be resilient.

Oval – as compared to round, stronger in one direction, weaker in the other. Installation direction can impact ability to withstand pressures and failing point. If "tall" it may take weight of snow, but wind from end to end may cause failure sooner than round.

Square – strong, weakest point is corners/edges where stress can accumulate, failure rate usually low however. Often sidewall thickness in square tubing thicker. Bends are a bit different as inside face has to be stretched inward uniformly, deforming original shape, to prevent wrinkling.

Rollform – process where flat stock is run through a series of rollers and guides, shaping the materials into a desired profile, resulting in a strong shape using otherwise lighter materials, that as flat would exhibit little strength or resistance to deflection.

Rectangle – not used much as a load bearing framing member, but often in door frames. Does not bend or form well.

Other – be it shape, wall thickness, weight, availability, durability, strength, how is it worked, does it meet cost vs benefit analysis?

FRAME TYPES - Quonset, semi Quonset, semi gable.

Quonset – typically ground to ground, semi circle frames and usually not more than 20 feet wide. Quonsets exhibit limited headroom as you approach the sidewall from the center, small interior volume, doesn't allow for much equipment mounted inside. Simple to build, lower materials costs and install costs, simple environment. Hard to manage interior temps if needed, best for winter protection cold frames or hardening off houses.

Semi Quonset – this is a modified Quonset but has vertical sidewalls of some height by design. Is suitable for 20 feet wide plus, can be taller peak, more side room use; add more equipment inside, can add a hanging crop (to some degree). Design of arch profile can lead to a "flat" run at the peak which means condensate has nowhere to go but fall. This can impact as much as a 6 foot wide section depending on the arch width. Usually this design, for interior volume of a 30 foot can be desirable, but is still considered low volume on a 20 foot wide. Volume and condensate control are the two primary considerations with this design. Know it going in and provide culturally for the conditions.

Semi Gable – can be 20 feet wide and common is 30 feet wide. Not used much in narrow widths, 20 feet and below as bends are too sharp and poly film fails from too much stress at bends. Often good access to sidewall because of vertical sides, and height can be changed. Flat run of roof ridge portion often less of a problem as ridge breaks over to roof slope sooner. Average condensate control because of slope from ridge to eave. Better internal volume than other designs, allows for equipment, taller crops, trusses are available if needed, and can support limited hanging weight.

Bears some merits of a true peak design, (gable style) without higher costs.

<u>PLACEMENT / ORIENTATION</u> – think of placement as how can optimum results be obtained for the purpose of a greenhouse. It needs light maximized, uninterrupted, and unshadowed. Are there weather conditions to consider such as high prevailing winds, flooding, distance to market, utilities, water, and workforce. There are sometimes reasons why Southeastern Oregon does not have more greenhouses. They have good light and often geothermal heat, but the weight of these attributes is overshadowed by <u>other</u> environment conditions, distance to market, channels to market(s) etc.

Orientation – in Oregon most greenhouses should have a ridge direction of N to S, and unless a gutter connect range, probably 6 feet between frames. While this is a universal statement, think of Salem as at the 45^{th} parallel. That puts the sun at 45 degrees, sometimes higher and sometimes lower as the year goes by. Generally, of the three greenhouse styles, Q, SQ and SG, they will all have a portion of the frame/roof area that will intercept light, at a 90 degree angle of incidence, at changing points through the day, during the course of the day / all year. Light that is intercepted by the greenhouse at 90 degree A of I has the best chance of being transmitted directly. The rest of the light will be considered indirect not having the potential of direct light. A desired trait of greenhouse covering is to transmit light at high levels, but to diffuse it as it passes through. Diffuse = scattered. Diffusing takes the intensity out of the light and makes more light energy available to more areas of the plant surface.

COVERING(S) -

Soft - Poly film single and double layer, 3,4,5 and 6 mil poly; clear and white; season and long life; energy savings / condensate control; light managing

Rigid – Polycarbonate, CPC and 8MM; acrylic, Plexiglas, glass, other?

Poly film benefits – low cost, quick to install, can be heavily featured as choices above indicate, very good covering for these applications. Single layer offers no energy savings, but in cold frames offer the protection level needed much of the time. Double layer poly is where you can stack benefits as you choose; energy saving, light, mils, life. Downside is an inflation fan needs to run constantly to keep separation of layers. This fan should pull air from outside greenhouse as air inside holds much more water, and in time will “fill” area between layers with water that will accumulate and “pond”, while reflecting light as it forms droplets between layers.

Most long life poly films naturally manage ultra violet light; some are more managing than others. Too little UV light and bumble bees can’t see. They will go towards exits where natural light is present and be gone. So much for crop pollination.

Best proven poly film installation is clear, 4 year 6 mil double layer; using an IR (infra red retention) AC (anti condensate) inside layer and a clear, 4 year, 6 mil top layer. The IRAC layer is correctly installed when you can read the printed text on the film while standing inside. Do not use two layers of IRAC expecting more heat savings; the light sacrifice is too much.

Rigid – type used most frequent is polycarbonate (PC); of the PC there are two most common – corrugated (CPC) and 8MM multi wall (8MM). There is clear, solarsoft, textured, opal and smoke. The PC providing par light (light plants use for growth known as “photosynthetically active radiation” PAR) is clear, textured and solarsoft. PC is easy to work with and long lasting. It is directional in that sides are dedicated to inside and outside facing, for benefits of UV resistance and condensate control. Long lasting and can be energy saving, very durable, good growing conditions, low to moderate expense.

8MM requires installation hardware, and techniques specific to 8MM to install. Typically 8MM is perched above framing members by using extrusions and fastener systems for installation. Is energy saving, long life, little maintenance, can be the most expensive of the options.

There are many versions of PC, be it corrugated or multi wall. Some multi wall products come as thick as 16mm and offer up to 5 layers. Many are not suitable for growing as they block too much light, and become too expensive. Keep mind also what is available for replacement should you need a panel or two. Many PC products are made for greenhouses and are manufactured with a UV stabilizer for one surface and a condensate product in the inside face. Many PC panels at building centers may not incorporate both features.

Poly film and PC products are not compatible with PVC. Poly film will become brittle and fail too soon, and PC products will first “craze” then shatter as they breakdown where in contact with PVC. PVC also does not provide a good attachment foundation for application of these materials to be securely fastened to frame.

Other products used – acrylic, Plexiglas, fiberglass and glass. To some degree these have all been used, but over time fallen out of favor as other products gained in performance. This shakes down to a cost vs. benefit as a building component, and plant performing product, does it grow a good plant?

<u>ACCESS</u> – plan your traffic in and out of the greenhouse. How many doors, how wide, swinging or single / double sliding; overhead; end or side doors; equipment access needed?

Door within door – not too often, can be done for $$$$

<u>PLANT / MATERIAL HANDLING</u> –

Beds - longitudinal or peninsular, surface or raised

Benches – long. or penin, rolling stationary or portable, legs in footings or slab mount?

Walkway width, location(s); gravel, concrete

How does or will handing equipment serve planting area(s)

Will heat system be incorporated?

How will the planting area be irrigated?

Will micro climates to be used or needed, as in tenting?

Cart or overhead trolley access?

Pick up / set down flats, pots, trays

What comes into and leaves greenhouse should be efficiently moved, this is mostly labor which is a dollar/time event. Will the plant live its life where it is first put down, can environment change to meet plant needs, and how global is environment?

IRRIGATION – fog, mist, hand watering, overhead sprinklers, drip, capillary, flood, boom irrigation.

Some of this is cultural while some deals in labor savings and efficiency. Unless you truly need fog, discount it because fog requires hi pressure pumps, hi pressure stainless lines, hi level of filtration and on and on.

Mist on the other hand is simpler; its success can be measured by the controller. Mist usually is concerned with propagation and seed germ

Hand watering is a skilled function, should be trained as a skill, and performed with thinking. It is also expensive for the return.

Drip and overhead can be used together as current product lend themselves to be thought of as micro devices, applying calculated amounts of water to a plant, or growing area, reducing the wasted water from other delivery methods. Inexpensive for the return.

Capillary is an efficient water delivery type, that moisture is pulled into the soil profile, assuming the pot has drain holes in contact with cap mat. When the water profile in the cap mat drops, the excess water in the soil caps drains down, replacing what would be a saturated condition, with one that is hi in air / water. Install costs are not high, but returns are. Annual maintenance required and not all planting types will work on cap mats.

Flood, same concept as cap mats, but expensive to purchase and install. High maintenance required, may be a disease problem as well.

Boom irrigation – has merits of specific, calculated amount of water delivery. If your plants can stand overhead irrigation, boom offers the most uniformity, flexibility, cost savings and can be automated.

<u>CLIMATE CONTROL</u> – natural or artificial, either way ask "is there backup regardless of choice"?

HEAT – space / convection, air to air – inefficient but inexpensive

Conduction / Convection – often as hot water, more efficient and more expensive. A lot of technology is being gained on hot water greenhouse heating. Days ago there was a lot of steam produced in high mass boilers that burned lotsa fuel oil, up to a crude grade. Today there are low mass boilers, which heat on demand, to much lower temps, and are condensing style. Much of the heat energy conversion from the fuel to heat sink takes place at much higher rate, +90%. Usually water is the medium, which has a good transfer rate, which in turn is distributed into the growing area to exchange the stored heat to the plant. More efficient than space heat, less cost to operate, more cost to set up and install.

Infra Red heat – can be considered one the most expensive but also the most efficient. If the type is a "vacuum", the tubes and burners are made of materials that transfer heat at different rates and reflectors are shaped so a 2 to 1 heat pattern exists; infra red has many benefits, here are some: low <u>installation</u> costs, equipment small relative to output, no products of combustion can enter greenhouse because system operates under vacuum, IR heat is like Sunlight, the surface it impacts will be warmer than environment resulting in very low disease pressure, systems have lasted more than 20 years in a greenhouse.

VENTING – passive or active, includes air circulation

Passive – roof / side vent, roll up or drop down walls; remove covering.

Active – fans, air circulation. Equipment required, energy, maybe water, maintenance.

Passive – live with ability of design, more opening means more venting. This can cycle a lot and need to allow greater variance to control. Costs not high and often performance is sufficient.

Active – tighter control, consumes energy. Can design for tight tolerance to climate change, first - design to optimum, then step down performance based on expectations. Equipment included might be exhaust fans using multiple speed motors and/or be different sizes, intake shutters or wall vents, evaporative pad systems, mist or fog systems, humidity control(s)

Air circulation is part of active ventilation. This uses any means to keep a constant flow of air inside greenhouse. Should be gentle and involve the entire area. Helps keep plants dry – less disease; slows heat stratifying; keeps O_2 and CO_2 moving around as plants are looking for CO_2.

LIGHT MANAGEMENT – light is the one free resource, how is it going to be utilized?

Light grows the crops, heats the greenhouse, can be a mood modifier ☺

Should you shade, what to use, where to put it, is it changeable depending on need, how is it applied, how will the plants respond, is this a people comfort – heat reducing or cultural need for the plants?

Sunlight is made of a spectrum of light colors, or wavelengths, some we see, some we feel. On a sunny day, high energy, short wave light impacts the greenhouse by passing through the covering. As light passes, it slows down from short lengths (UV and visible spectrum) to longer lengths that are felt as heat, such as infra red. Hence, we feel the heat gain. As the light is trapped in the greenhouse, it becomes hotter and hotter as the light accumulates. Here is where to consider what the application of shade is about and where to put it.

Plants use mostly blue and reds, and it is much more a balance of light colors, or wavelengths, that plants see, that produce "results". Too much blue light results in long internodes (generally) and too much or too little red, may impact germination.

If reducing light is a cultural objective plant response should be anticipated. You may see longer internodes, less "stocky" growth, or be what is needed as in the case of shade needing or tolerant species. Be prepared for plant "shock" when leaving a shade environment to go outside. Too much UV means unhappy tissue.

Should shade be on the inside or out? Shade has to prevent light rays from getting into greenhouse if heat reduction is the objective. If shade is inside it will only reduce light. Note: shade fabric must cover <u>all</u> areas to constitute the % shade the fabric claims to be, before the % will be achieved.

Does shade need to be in place all day? Mechanical systems offer the choice of being drawn determined by need. These types often double as heat retention at night as they are "closed" at sunset until just before sunrise, to reflect long wave radiation back into the greenhouse space below the fabric. These systems are installed inside the frame, and work good with passive ventilation and active if needed.

ARTIFICIAL LIGHT – Suffice it to say, lights are available for any purpose whether there is natural light available or not. Be prepared to answer the question, "**what are you growing"**?

But generally, artificial light is used for special purposes in smaller areas of a greenhouse. It may be to aid in germ, induce bloom, inhibit bud formation, extend day length, or interrupt the night.

Light are expensive and use a lot of energy. I am not down on lights; I routinely see them used for specific, return on investment, uses. Know what you are looking for when adding lights. <u>Let the light suppliers do the light design, they have the resources to maximize this device.</u>

<u>ENVIRONMENT CONTROL MANAGER</u> –

This is more than a thermostat, although a stat can be considered to be in this family.

Thermostat (TS) problems are – one device or appliance = one thermostat. Often line voltage is switched at the TS, putting line voltage in the growing environment which = the people environment. Sometimes these people have hoses and spray equipment – go figure why. TS are also an analogue control, and from TS to TS often see temps different, even though they are side by side.

Enter the Computer Environment Manager – These consist of a zone sensor, typically specific to the environment type being sampled and handled by only one sensor; a brain that makes adjustable, programmed decisions based on sensor input(s), and runs that signal through a pre wired contactor cabinet that contains the relays and contactors for electric motor protection that run the devices in the "field" that control greenhouse environment. All that is overstating it, but the objective is to integrate the controls into one device so equipment does not operate in conflict, maximizes known avenues of energy efficiency, and does it safely.

Don't heat and vent at the same time; don't heat the greenhouse at 10 mins before sunrise if the anticipated light gain will cause overheating and the greenhouse have to be vented; converse it true too, don't vent 30 mins before sunset just to turn on the heat.

How about utilizing DIF – assume the plant environment becomes CO2 poor at night and O2 rich, plants are wanting a CO2 rich environment at dawn and can benefit from a pre dawn purge which brings in a fresh air – more CO2, cools the tissue and works like a PGR to control plant height, etc.

Managers give the grower the flexibility to select day / night setbacks and in some cases, morning / afternoon setbacks as well. They know time of day, day of year, location by latitude, often sense outside conditions. Managers can run equipment in “step” fashion and other by proportional means. Heat and cool settings are usually a pre determined, but changeable, distance apart, therms are either on or off at one temp only. Equipment can run with as little as 1 degree separation or as many degrees as the grower wants to program. This is often different as the device that is going to be run is either for the temp falling or rising.

Managers will not “re fire” all equipment back on line in the event of a power failure. They will stage return operation of the devices needed.

Managers can have an upfront cost that seems high – $2 - $5K in many cases for a single zone environment. Check to see if there are energy rebates available, typically this equipment pays, it does not cost; may have expansion capability; can record and download event(s) and be viewed on a PC; remote monitoring and changes are available. Growers can utilize event recording to review what went on during a crop cycle. They can see temps in the greenhouse and outside temp, what equipment functioned, what days and for how long.

Greenhouse set up calculations:

Most all conditions in a greenhouse use a "standard" by which choices are made for heating, cooling, lighting etc., using industry accepted formulas that determine values for the equipment based on a standard set of conditions. Within these formulas are variables that take into account elevation, wind, light level, equipment distances within a greenhouse, covering type(s) and so on. There is not currently a formula that grows plants, but there is a program in one of the most sophisticated controllers that will execute a multi function, pesticide application event.

Greenhouse heating is determined by covering surface area and type, not interior volume.

Greenhouse fans are sized by square footage in an area 8 feet high. This is where the plants are most likely to be found, in the first 8 feet from the ground in a greenhouse. Baskets are the exception, but may be as easy as placing the exhaust fans in the peak of the gable vs. at bench top.

Shading is grower discretion.

Lighting – give the lighting supplier the greenhouse spec and crop type, he will return a design that will maximize the investment.

Air Circulation – less science here, figure propeller style fans have an effective distance of moving air of 40 – 50 feet, and about 15 feet wide before it stops. Plan fans accordingly as a 30 x 96 will have 4 fans at an approximately 1500 cfm per fan. The concept here is continuous, gentle air movement. Note: if you have a mature hydroponic tomato crop, the air circulation needs will be well above this design for equipment size, spacing etc.

What have I missed? Please don't tell my boss!

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