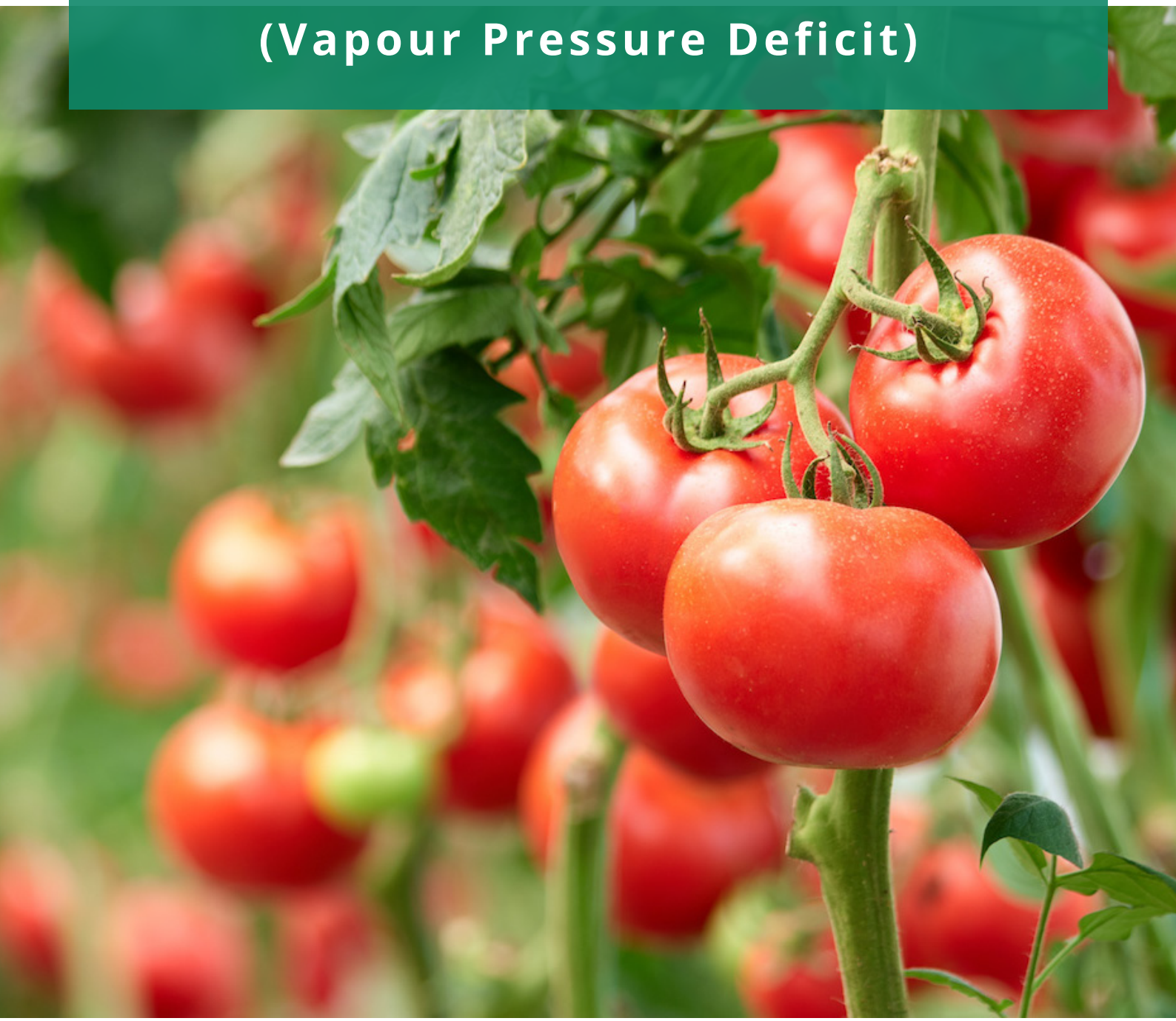
Pessl INSTRUMENTS

TURNING INFORMATION INTO PROFITS

Guide to VPD

(Vapour Pressure Deficit)



With VPD you can achieve the best results while avoiding pest and environmental problems. VPD also controls plant transpiration rates, stomata opening, CO2 uptake, nutrient uptake, and plant stress.

VPD is an indication that takes into account the effect of temperatures on the water-holding capacity of the air, which is what drives transpiration to the leaf surface. Transpiration occurs when water pressure in plant leaves is higher than the air vapour pressure.

1. INTRODUCTION

1.1 What is vapour pressure deficit?

If you have an iMETOS device with hygroclip sensor (air temperature and relative humidity) now you can also see Vapour pressure deficit values and chart in FieldClimate. Vapour pressure deficit (VPD) is a value calculated from relative humidity and air temperature, and is in a close relationship to evapotranspiration.

VPD is an indication that takes into account the effect of temperatures on the water-holding capacity of the air, which is what drives transpiration of the leaf surface (transpiration occures when water pressure in leaves is higher then air vapour pressure).

It is difference from the amount of moisture from the air and how much moisture the air can hold when it's saturated (100 % RH). When the air is saturated (vapour starts to condensate) the clouds will form, dew will form, and leaf wetness will appear.

If we have low VPD, this means that RH is high and transpiration is low, we also have leaf wetness. If we have high VPD, this means that RH is low, no leaf wetness, and plants need to draw more water with its roots – high transpiration.

°C	°F	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%
15	59	0.8	1.7	2.5	3.4	4.2	5.1	5.9	6.8	7.6	8.5	9.4	10.2	11.1
16	60.8	0.9	1.8	2.8	3.7	4.6	5.5	6.4	7.3	8.2	9.1	10.00	10.9	11.8
17	62.6	1.0	2.0	2.9	3.9	4.9	5.8	6.8	7.8	8.8	9.7	10.6	11.6	12.6
18	64.4	1.0	2.0	3.1	4.1	5.1	6.2	7.2	8.2	9.3	10.3	11.3	12.4	13.4
19	66.2	1.1	2.2	3.3	4.4	5.5	6.6	7.7	8.8	9.9	11.0	12.1	13.2	14.3
20	68	1.2	2.4	3.5	4.7	5.9	7.0	8.2	9.4	10.6	11.7	12.8	14.0	15.2
21	69.8	1.2	2.4	3.7	4.9	6.2	7.4	8.6	9.9	11.1	12.4	13.7	14.9	16.1
22	71.6	1.3	2.6	3.9	5.3	6.6	7.9	9.2	10.5	11.9	13.2	14.5	15.8	17.2
23	73.4	1.4	2.8	4.2	5.6	7.0	8.5	9.9	11.3	12.7	14.1	15.4	16.8	18.2
24	75.2	1.5	3.0	4.5	5.9	7.4	8.9	10.4	11.9	13.4	14.9	16.4	17.9	19.4
25	77	1.6	3.2	4.8	6.4	8.0	9.5	11.1	12.7	14.3	15.9	17.4	19.0	20.5
26	78.8	1.7	3.4	5.1	6.7	8.4	10.1	11.8	13.4	15.1	16.8	18.4	20.1	21.8
27	80.6	1.8	3.5	5.3	7.1	8.9	10.7	12.4	14.2	16.0	17.8	19.6	21.3	23.1
28	82.4	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.1	17.0	18.9	20.7	22.6	24.5
29	84.2	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.1	24.1	26.1
30	86	2.1	4.2	6.4	8.5	10.6	12.7	14.8	17.0	19.1	21.2	23.3	25.4	27.5
31	87.8	2.2	4.5	6.7	9.0	11.2	13.4	15.7	17.9	20.2	22.4	24.6	26.9	29.1
32	89.6	2.4	4.7	7.1	9.5	11.9	14.2	16.6	19.0	21.3	23.7	26.1	28.4	30.8
33	91.4	2.5	5.0	7.5	10.0	12.5	15.0	17.6	20.1	22.6	25.1	27.6	30.1	32.6
34	93.2	2.7	5.3	8.0	10.6	13.3	15.9	18.6	21.2	23.9	26.5	29.2	31.8	34.5
35	95	2.8	5.6	8.4	11.2	14.0	16.8	19.6	22.4	25.2	28.0	30.8	33.6	36.4

Table: Vapour pressure (mBar) at various air temperatures (°C) and relative humidities (%)

Seasonal monitoring of crop stress due High or Low VPD level is an important tool to appreciate and forecast crop yields once it was integrated in to a Farm Management Software (FMS)

It is a crucial parameter for indoor crops (Greenhouses), VPD is superior than temperature and humidity analyzed separately because it accounts for the relationship of temperature and humidity.

1.2 WHAT IS NEEDED FOR CALCULATION?

- **Air temperature**
- **Relative humidity**

We can then calculate the saturation pressure. Saturation pressure can be looked up in a psychrometric chart or derived from the Arrhenius equation, a way to compute it directly from temperature is:

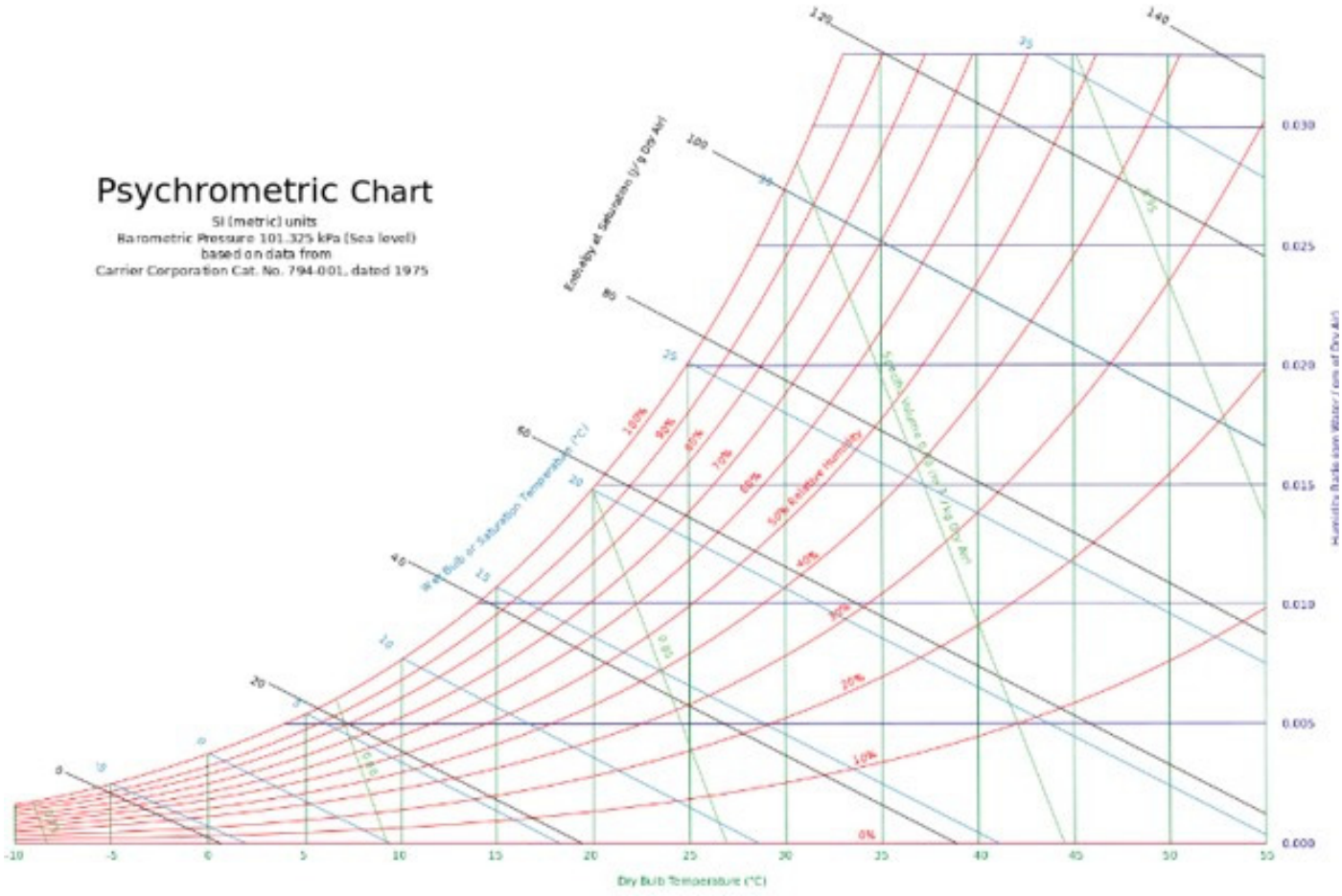


Figure 1: Psychrometric chart

1.3 HOW IS IT SHOWN IN FIELDCLIMATE?

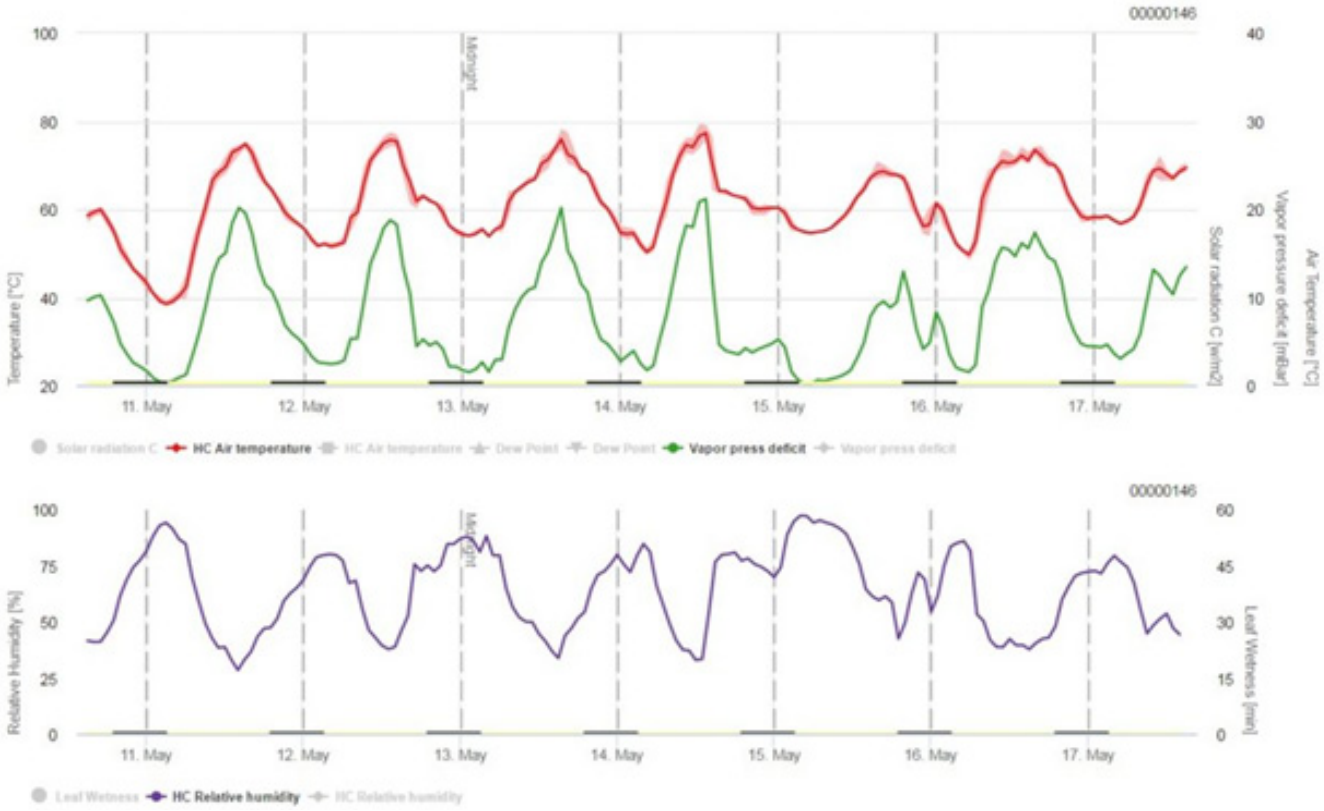


Figure 2: VPD Chart on FieldClimate showing vapour pressure deficit (mBar), air temperature (°C) and relative humidity (%).

2. USE CASES

2.1 TOO HIGH VPD

Rate of evapotranspiration from the leaves can exceed the supply of water through the roots – the stomata will close and photosyntesis will slow down or stop. Leaves are at risk of high temperature injury, since evaporative cooling is reduced.

To avoid injury and death from wilting, many plant species will either curl their leaves or orient them downwards in an attempt to expose less surface area to the sun. This can downgrade the quality of potted and foliage plants and can also reduce the growth rate and quality of vegetable crops.

TYPICAL VPD - 4-8 TEMP	OPTIMUM RH	ACCEPTABLE RH
19-20°C	70%	65-85%
21-22°C	75%	70-90%
23-24°C	80%	75-95%
25-26°C	85%	80-95%
27-28°C	90%	85-95%

VPD for non-excessive transpiration	4 – 8mb
VPD for healthy transpiration	8 – 12mb
VPD for high transpiration	12 – 16mb

2.2 TOO LOW VPD (humidity too high)

- Plants are unable to evaporate enough water to enable the transport of minerals (calcium) to growing plant cells, even that the stomata may be fully open.
- At extremly low VPD water may condens onto leaves, fruits and other plant parts. This can provide a medium for fungal growth and disease.
- At low VPD also gutation can occur (plant exude water from their leaf cells).
- When plants are unable to evaporate water, excessive turgor pressure within cells can cause splitting and cracking of fruits (for example tomato).
- In cases where VPD alternates between too high and too low, fruit quality can be adversely affected by shrink cracks in the skin of the fruit, as turgor pressure alternately expands and contracts the water-filled cells in the fruit.

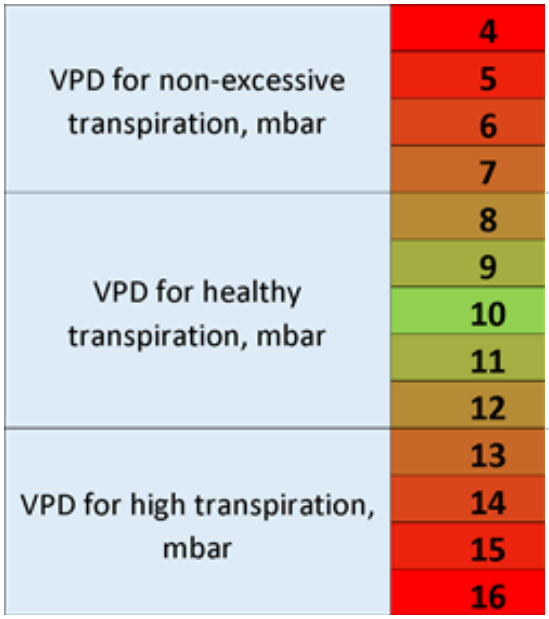
2.3 USE OF VPD IN NURSERY

1. Newly rooted cutlings or just germinated seedlings or young plants, with limited foliage and a small root system. This plants should have low transpiration, so we need to keep them at low VPD (4 – 8 mbar) in order to achive that high RH must be established (depending on temperature).

2. Good established plants, with developed foliage and root system. This plants should have higher VPD (8 – 12 mbar), that means we need to keep low RH (depending on temperature), and that we have high transpiration. We achive with that:
    - More healthy plants, because of lower diseases pressure (low RH).
    - More nutrients uptake, because of more root system activity (high transpiration), also more water uptake.
    - If we keep high VPD at lower temperature (higher RH), we will avoid transpiration stress.

2. VPD Application - overview

- You should care because VPD is a superior way of evaluating potential water stress. It's not a direct measurement of water flow or water loss, but it's an indicator of potential stress.
- Stress occurs at low or high vapor pressure deficit because it affects whether your plants can breathe or not!
- Vapor pressure deficit readings (VPD) tell you precisely how atmospheric factors are affecting your plants ability to take in and transpire water.



Lower VPD

- Transpiration is stifled by inability to release moisture to the air
- Moisture on plant surfaces leads to disease problems

Optimal VPD

- All processes under normal

Higher VPD

- Transpiration is unhindered
- Plants can dry out

Too high or too low vapor pressure deficits cause troubles such as:

- Your plants shutting down C02 intake photosynthesis stops or slows down.
- Your plants taking in too much water, so they take in too many nutrients and get burned.
- Your plants unable to transpire enough water, so their metabolism, water, and nutrients intake are negatively affected.
- Your plants' leaves becoming susceptible to molds, fungi, pests, and other problems.
- Clones and seedlings struggle or die.
- Buds get moldy.
- Powdery mildew spreads like wildfire.

4. LITERATURE

- http://msue.anr.msu.edu/news/why_should_greenhouse_growers_pay_attention_to_vapor_pressure_deficit_and_n
- http://www.growell.co.uk/blog/2014/06/temperature-relative-humidity-and-vapour-pressure-deficit
- https://nature.berkeley.edu/biometlab/espm129/overheads/Lecture_15_ESPM_129_Humdity_part_2_Overheads_2014.pdf
- https://www.academia.edu/28070910/Membership_Function_Model_for_Defining_Optimality_of_Vapor_Pressure_Deficit_in_Closed-field_Cultivation_of_Tomato
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC543035/pdf/plntphys00129-0121.pdf
- http://www.arguscontrols.com/resources/VPD_Application_Note.pdf

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