

냉난방 수배관의 Energy ICT Solution

박동일

공학박사/대표 박동일

CONTENTS

- 세계 에너지소모 동향
- 온실가스 & 에너지 감축 제안
- Hydronic Engineering
- 에너지 ICT Solution
- Coil. Control V/V. BAS
- Control Valve의 Authority
- 적용 사례

Energy ICT Solution

Hydronic engineering for HVAC System



에너지 소모량



전세계 에너지 소비의 40%가
빌딩에서 사용

> USD 1.28 tri

그중 50%가 HVAC 시스템에서
사용

> USD 640 bil

HVAC 시스템 효율
30% 이상 향상

> USD 192 bil

(*) Sources: European Commission EPBD (point 6, pp1) & US Department of Energy's "Buildings Energy Data Book"

에너지 30% 절감 제안

HVAC 시스템
에너지 절감 30% 향상
가능함

- 실내온도 편차를 $\pm 0.5^{\circ}\text{C}$ 로 유지(Modulating Control)
- Max Pump Head를 20~30m 이내 유지
- 환수온도를 13~15 $^{\circ}\text{C}$ 이상으로 유지
- 과유량, 저유량 방지 (Any Load)
- 배관 최적화 설계를 위한 전산화 Program 사용
- 부분부하 운전시 수배관내 측정, 진단, 조정 T&C Report 제출 의무화

(*) ASHRAE Fundamental

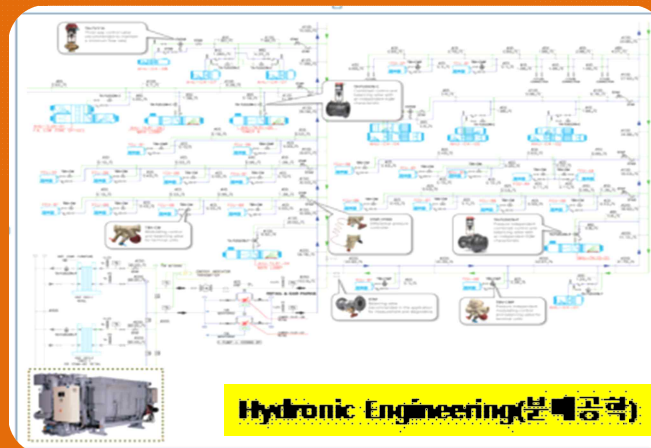
Hydronic Engineering



BEMS
측정,
분석,
지시,
기록



열원을 설계 부하량으로 각 사용처에 공급



Hydronic Engineering(분배공학)



설계부하대로 부분부하시 최적의 유량을 제어
및 현수온도 $\Delta t 5^{\circ}\text{C}$ 이상 유지

EQM특성 Valve 사용
Control Valve Authority 0.25(Good) 이상
KV's 값을 조정 할 수 있는 Valve 적용
Control Valve Rangeability 100% 사용



열원 생산 : 냉수 7°C

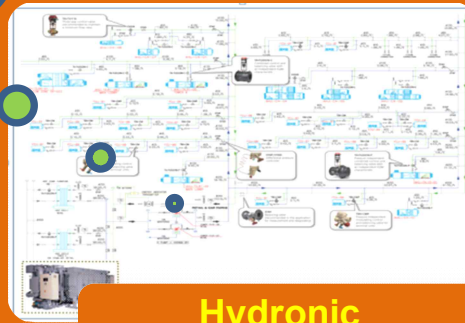
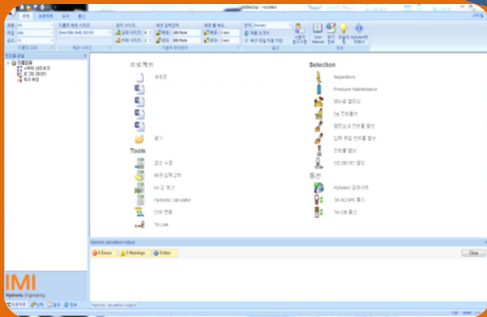


열원을 사용처까지 수송

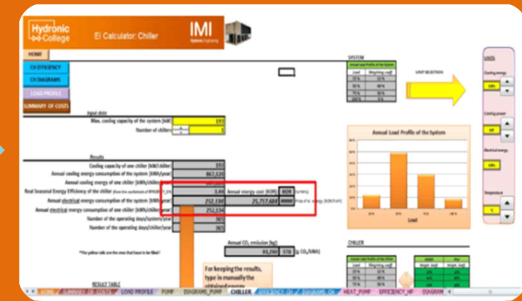
ICT Solution (B.M.W) 구성요소

Energy ICT Solution (B.M.W)

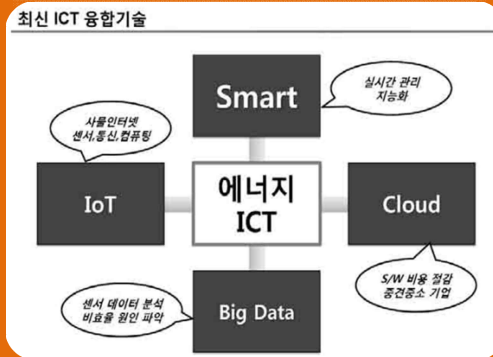
Why ICT=B.M.W Solution ?



Hydronic engineering



Big Data



Wearable

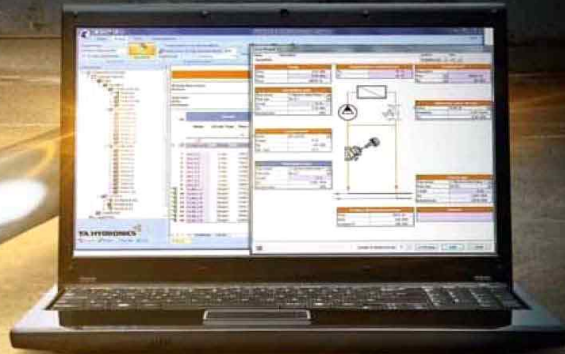


Mobile



Hydronic Innovation Technology Big Data-Program

MEASUREMENT & DIAGNOSTICS



**TA SELECT 4
- EFFICIENT DESIGN TOOL**
This computer program helps you to achieve the most cost-efficient hydronic design and lifetime operation. Using TA Select 4, you can determine key variables such as the optimal valve size and pre-setting values, required pump head and a list of optimally sized products. By connecting with the TA-SCOPE you can easily download or upload data making the balancing procedure easier and faster.

**TA-SCOPE
- PUTS CONTROL IN THE PALM OF YOUR HAND**
TA-SCOPE makes balancing a building's HVAC system a faster, easier and more precise task, with the upshot of greatly reduced energy use and costs. Its user-friendly interface provides a complete system overview and enables the use of advanced balancing methods and diagnostic functions. Key features include TA-Diagnostic, which detects system errors, allowing for easy maintenance, troubleshooting and building balancing calculations. Self-sealing needles with integrated temperature sensors make measurement safer and more accurate.

Return

- ✓ Pump Head의 최소값 계산
- ✓ 최적의 배관 Size 계산
- ✓ Control Valve Authority 계산
- ✓ Pump의 Index 순환로 확인
- ✓ 전체 수배관 시스템 설정 & 밸런싱
- ✓ 시스템 & 독립적인 순환로 분석
- ✓ 전체 배관의 길이 및 관경 계산
- ✓ 팽창탱크 선정용 체적 유량 계산
- ✓ 투자비의 경제성 (ROI) 검토
- ✓ 연간 CO2배출량 산출

Item	Value
Cooling capacity of one chiller [kW/chiller]	110
Annual cooling energy consumption of the system [kWh/year]	862,220
Annual cooling energy of one chiller [kWh/chiller]	7,838
Real Seasonal Energy Efficiency of the chiller [kWhe/kWhchiller]	0.840
Annual electrical energy consumption of the system [kWh/year]	252,134
Annual electrical energy consumption of one chiller [kWh/chiller/year]	232,630
Number of the operating days/system/year	365
Number of the operating days/chiller/year	365
Annual CO ₂ emission [kg]	83,280
Annual CO ₂ emission [kg CO ₂ /kWhe]	376

CHILLER

Item	Value
Load at 50% COP	30%
Load at 60% COP	40%
Load at 70% COP	50%
Load at 80% COP	60%
Load at 90% COP	70%
Load at 100% COP	80%

to control your hydronic system from design stage throughout the building's lifetime.

ering
NS
ATEX
ER

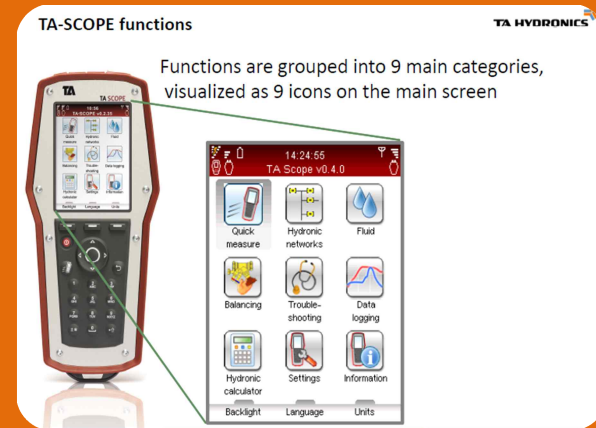
Hydronic Innovation Technology

Mobile-Scope (측정, 진단, 조정, Data전송)

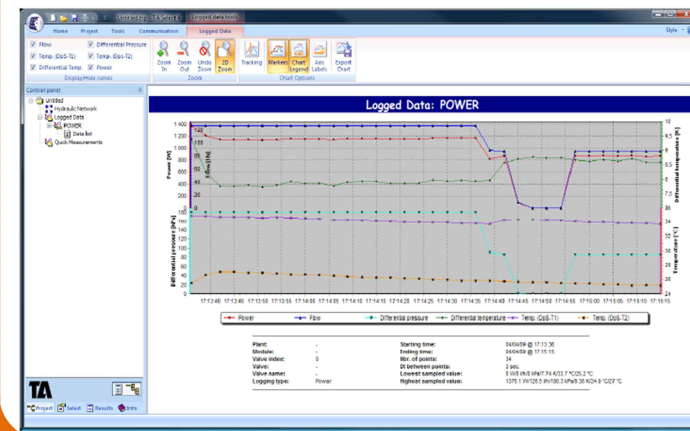
* T&C 검증 Tool



- ✓ 유량(q)
- ✓ 차압(Dp)
- ✓ 온도(T)
- ✓ 온도차(DT)
- ✓ 동력(P)
- ✓ DATA 통신



Viewing logged data chart on TA Select



Hydronic Innovation Technology Wareable



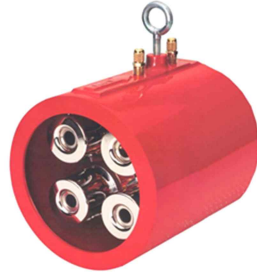
TA-BV-CMP
Pressure Independent Balancing and Control Valve (PIBCV)
- DN 15-25



TA-COMPACT-P
Pressure-Independent Balancing and Control Valve



TA-FDI
Automatic Balancing Valve
- DN 15-500

DA 516, DAF 516
Differential pressure controller with adjustable set-point
- DN 15-150



TA-PILOT-R
- DN 65-200



STAP
- DN 15-50



DN 65-100



TA-FUSION-P
Pressure-Independent Balancing and Control Valve



SINGAPORE GREEN BUILDING COUNCIL

SINGAPORE GREEN BUILDING PRODUCT CERTIFICATE

AWARDED TO
TA Hydronics Pte Ltd
223SG, Akuriballon
223 Akuriballon Road
803-01
Singapore 398008

FOR THE PRODUCT
Actuators & Valves

PRODUCT RANGE
TA Hydronics

STAP DN 15-50

THE PRODUCT HAS BEEN ASSESSED ACCORDING TO THE ASSESSMENT CRITERIA OF THE SINGAPORE GREEN BUILDING PRODUCT CERTIFICATION SCHEME. IT HAS BEEN AWARDED THE DATAS:

Rizky Kiany
Director
SIBC Pte Ltd

Certificate Number: S0999C-14-290 Original Issue Date: 29th March 2014 Last Revision Date: Valid To: 29th March 2016


Good Very Good Excellent Leader

The use and reliance on this certificate is subject to the terms and conditions of the Singapore Green Building Product Certification Scheme. Issued certificates may also be issued at the discretion of the Council. The certificate details may be verified at the Singapore Green Building Council website (www.sgbc.sg).

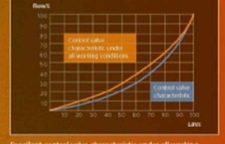


TA FUSION

An innovative range with one purpose – absolute control

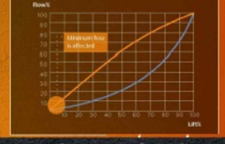


Excellent valve authority



Excellent control valve characteristic under all working conditions due to optimal authority

Poor valve authority



FULLY ADJUSTABLE KVS

Excellent valve authority: exceptional control

BAS & Energy Saving



ANSI/ASHRAE/IESNA Addendum ad to
ANSI/ASHRAE/IESNA Standard 90.1-2004

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on February 3, 2006; by the ASHRAE Board of Directors on February 10, 2006; and by the American National Standards Institute on March 11, 2006.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, <http://www.ashrae.org>, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2306. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4722 (for orders in U.S. and Canada).

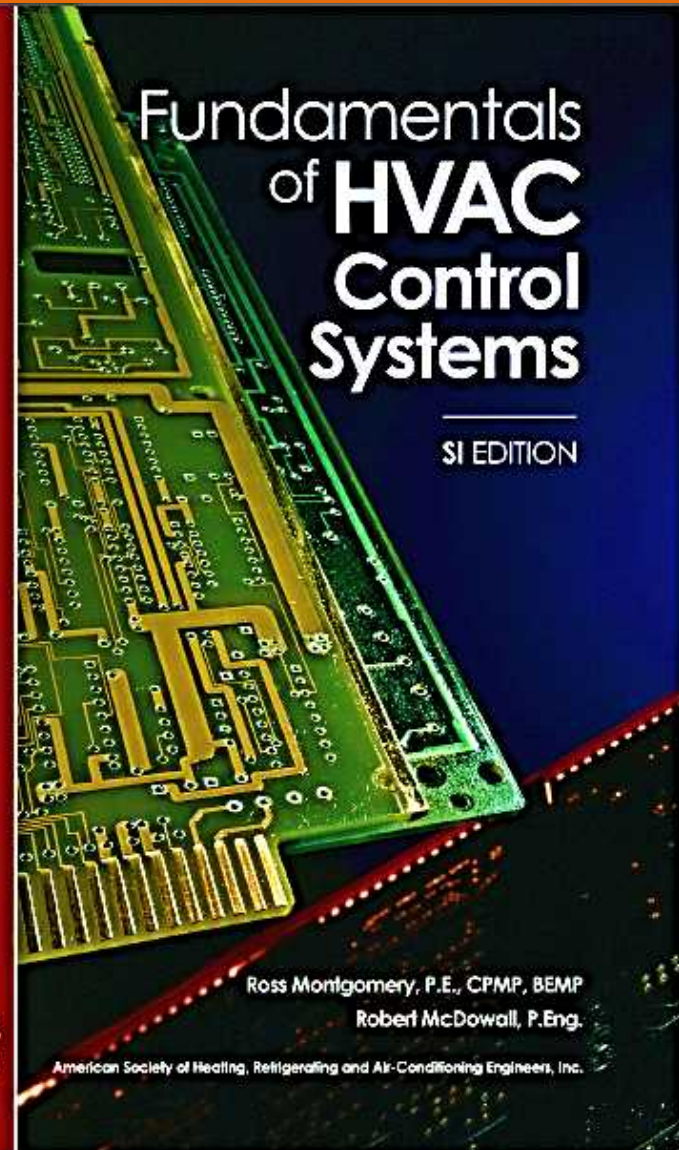
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When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at <http://www.ashrae.org>.



American Society of Heating, Refrigerating
and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org



Fundamentals of HVAC Control Systems

SI EDITION

Ross Montgomery, P.E., CPMP, BEMP
Robert McDowall, P.Eng.



American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Terminal. Control valve. BAS

- ❖ 유량과 차압 관계
- ❖ Coil 성능특성(ASHRAE 90.1)
- ❖ Valve 성능 특성
- ❖ Terminal 과 Valve의 관계
- ❖ Control Valve의 **Authority**
- ❖ PIBCV

Terminal. Control valve. BAS

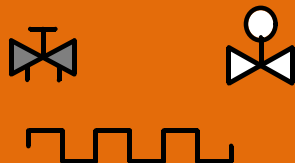
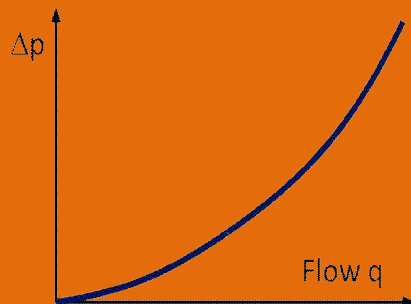
- ❖ 유량과 차압 관계
- ❖ Coil 성능특성(ASHRAE 90.1)
- ❖ Valve 성능 특성
- ❖ Terminal 과 Valve의 관계
- ❖ Control Valve의 **Authority**
- ❖ PIBCV

유량 & 차압 관계

밸브, 배관, 코일, 냉동기, 열교환기 등등...

$$\Delta p \propto q^2$$

$$q \propto \sqrt{\Delta p}$$



만약 유량이 4배가 되면 (x4), 압력 강하는 2배가 된다. (x2).

Example :

- ✓ q increases 15%, Δp increase is $1.15^2 - 1 = 0.32$ (32%)
- ✓ Δp increases 20%, the flow increase is $1.2^{0.5} - 1 = 0.1$ (10%)
- ✓ q reduces 40%, Δp reduced is $1 - 0.6^2 = 0.64$ (64%)

Terminal. Control valve. BAS

- ❖ 유량과 차압 관계
- ❖ **Coil 성능특성(ASHRAE 90.1)**
- ❖ Valve 성능 특성
- ❖ Terminal 과 Valve의 관계
- ❖ Control Valve의 **Authority**
- ❖ PIBCV

Cooling Coil – Performance Characteristic

38.8

AHU/FCU Performance Characteristic

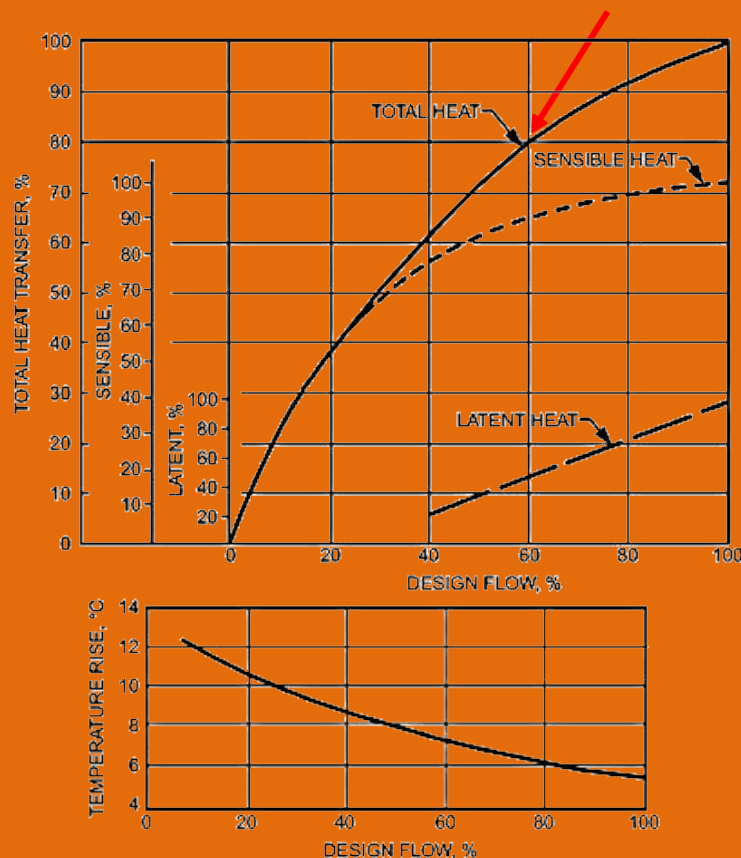


Fig. 4 Chilled Water Terminal Heat Transfer Versus Flow

2011 ASHRAE Handbook—HVAC Applications (SI)

- Dynamic balancing valves or flow-limiting valves (for prebalanced systems only); field adjustment of these devices is not normally required or possible (see Chapter 46)
- Pumps with factory-certified pump curves
- Components used as flowmeters (terminal coils, chillers, heat exchangers, or control valves if using manufacturer's factory-certified flow versus pressure drop curves)

Record Keeping

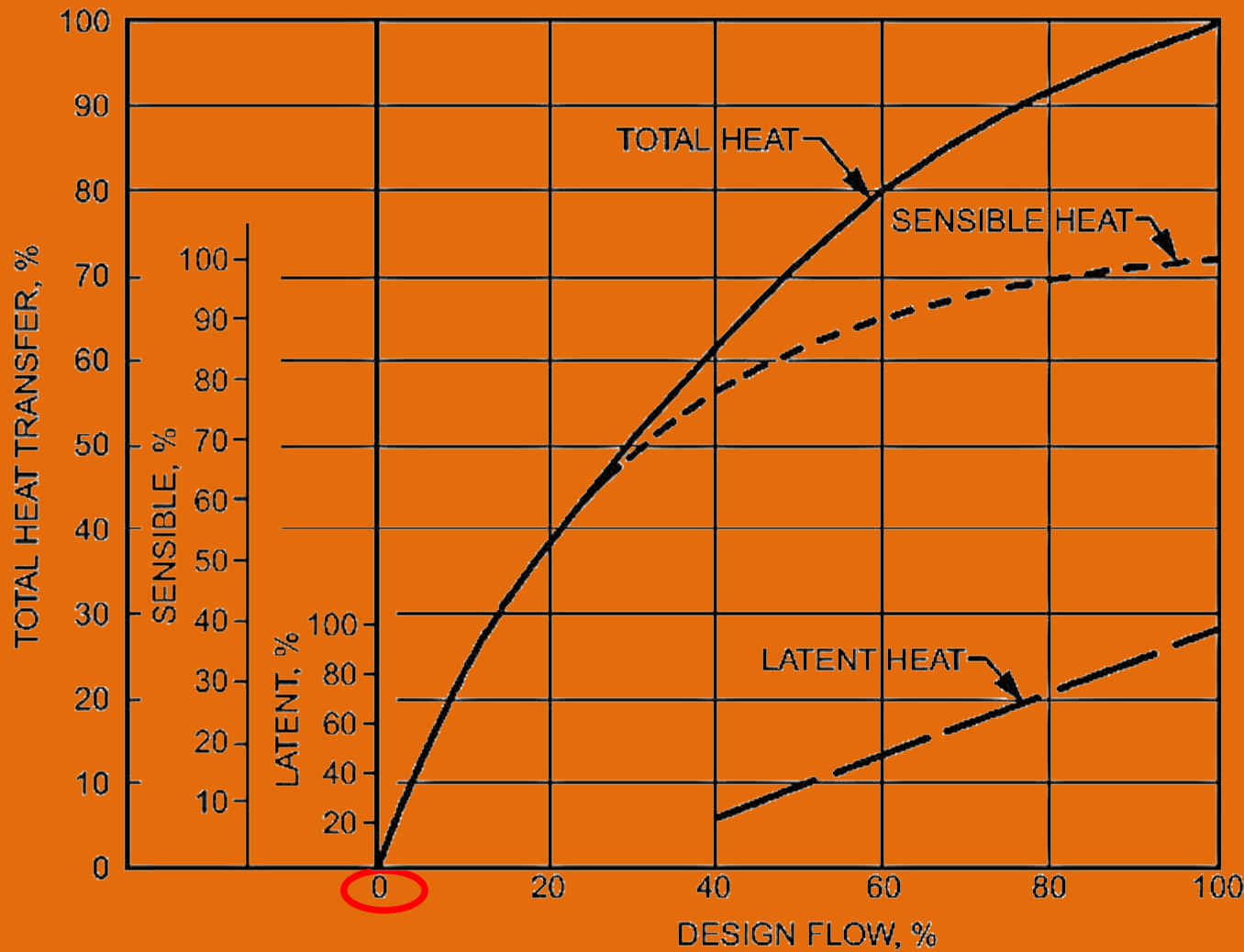
Balancing requires accurate record keeping while making field measurements. Dated and signed field test reports help the designer or customer in work approval, and the owner has a valuable reference when documenting future changes.

Sizing Balancing Valves

A balancing valve is placed in the system to adjust water flow to a terminal, branch, zone, riser, or main. It should be located on the leaving side of the hydronic branch. General branch layout is from takeoff to entering service valve, then to the coil, control valve, and balancing/service valve. Pressure is thereby left on the coil, helping keep dissolved air in solution and preventing false balance problems resulting from air bind.

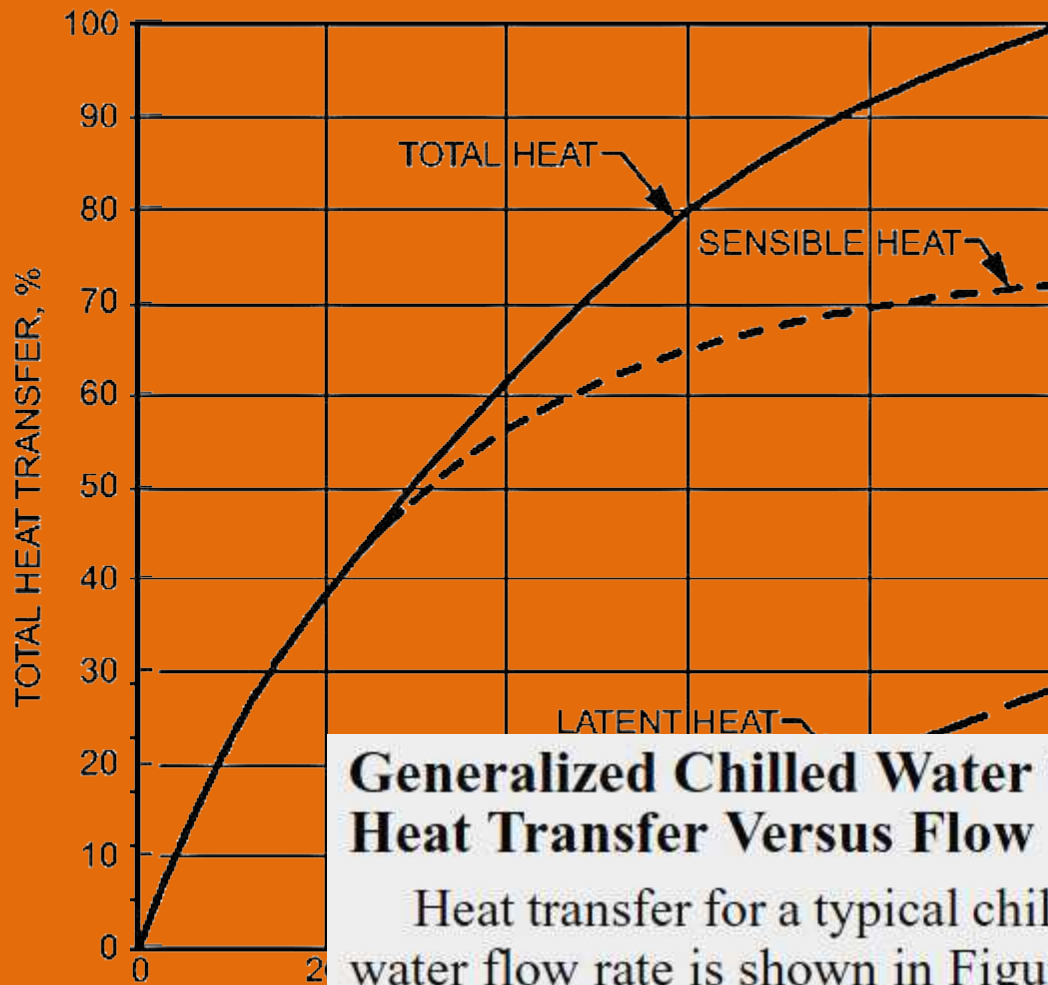
A common valve sizing method is to select for line size; however, balancing valves should be selected to pass design flows when near or at their fully open position with 3 kPa minimum pressure drop. Larger Δp is recommended for accurate pressure readings. Many balancing valves and measuring meters give an accuracy of $\pm 5\%$ of range down to a pressure drop of 3 kPa with the balancing valve

Cooling Coil – Performance Characteristic



“Terminal unit” characteristic

Cooling Coil – Performance Characteristic



ASHRAE Handbook Article 38.7

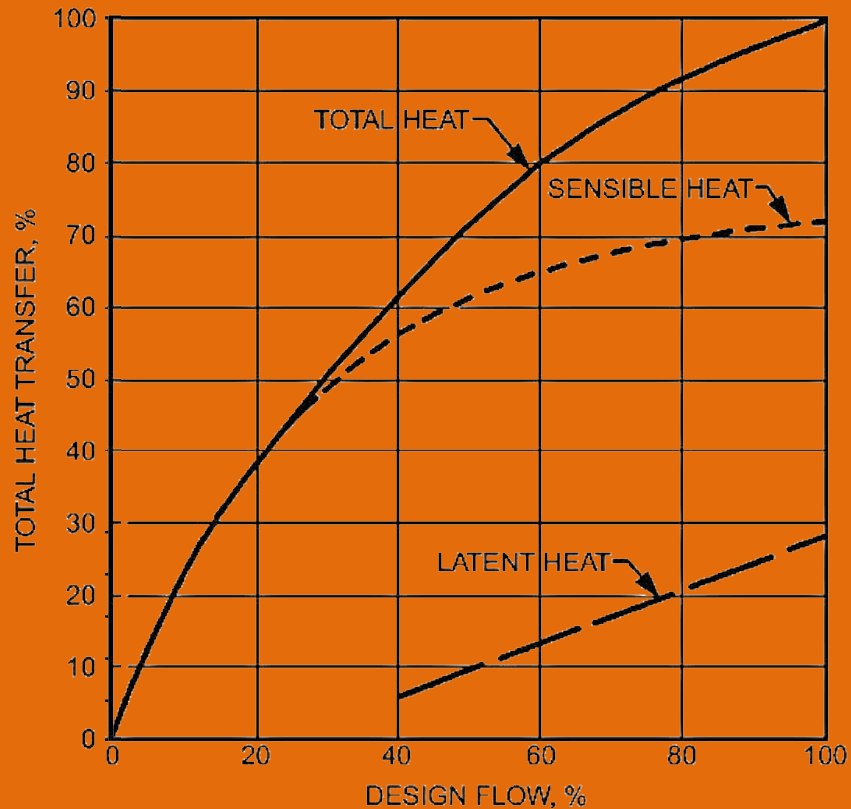
- Outlet water is 12.8 degC
This coil characteristic is therefore based on
- Inlet water = 7.2 degC
 - Outlet water = 12.8 degC

Generalized Chilled Water Terminal Heat Transfer Versus Flow

Heat transfer for a typical chilled-water coil in an air duct versus water flow rate is shown in Figure 4. The curves are based on ARI rating points: 7.2°C inlet water at a 5.6 K rise with entering air at 26.7°C db and 19.4°C wb. The basic curve applies to catalog ratings

“Termin

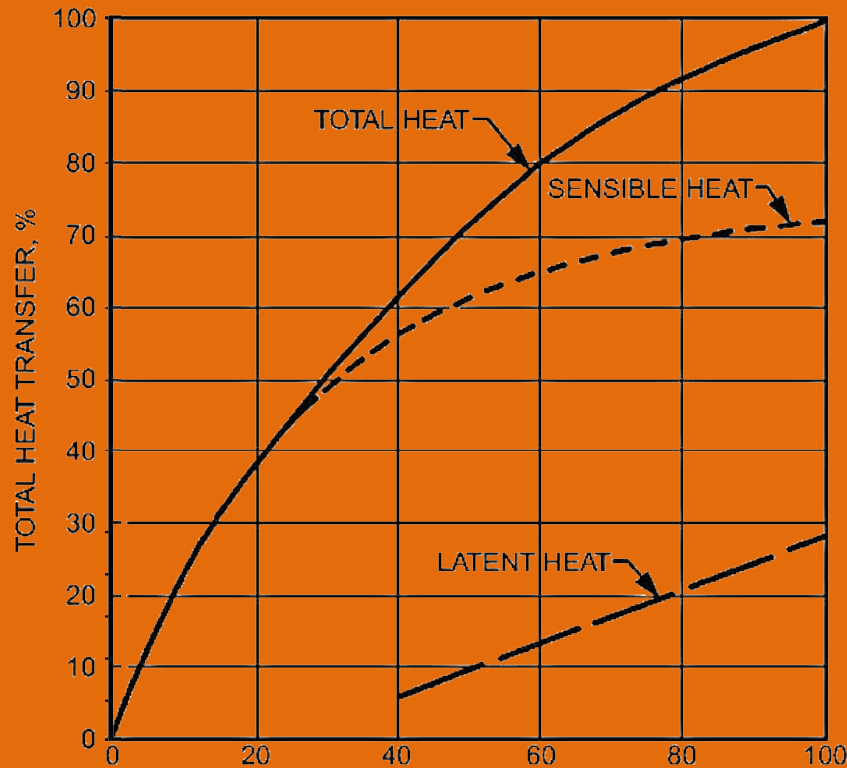
Cooling Coil – Performance Characteristic



This coil characteristic is therefore based on

- Inlet water = 7.2 °C
- Outlet water = 12.8 °C

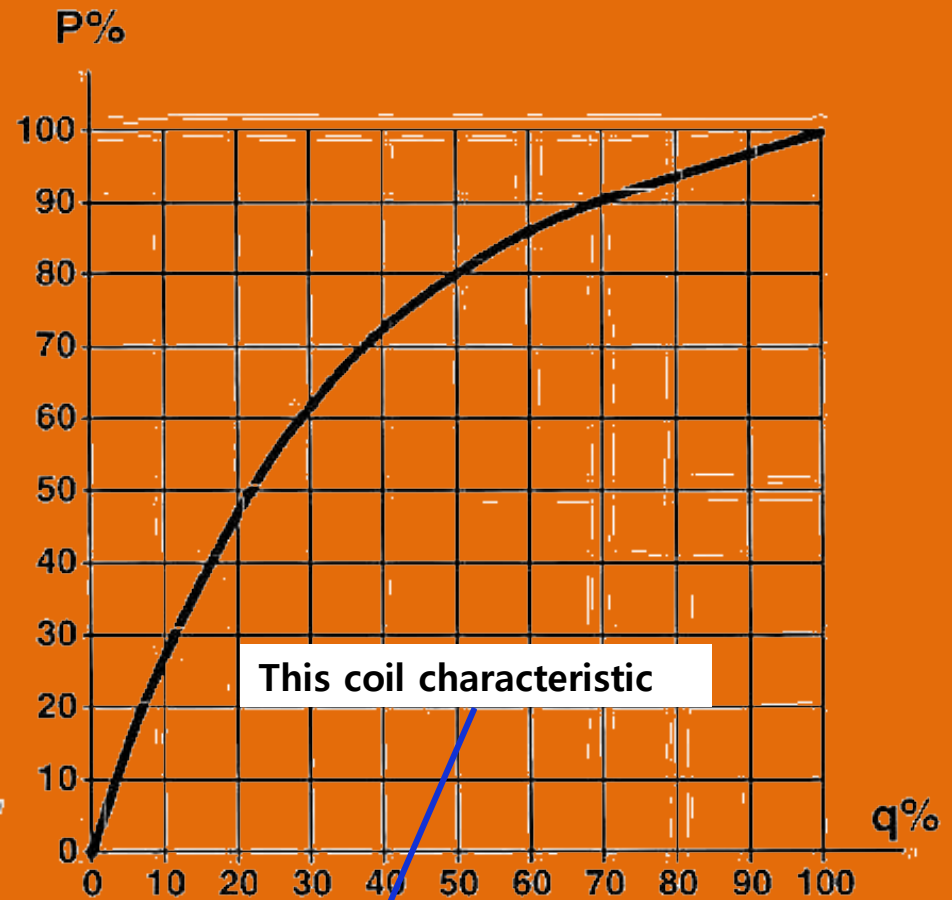
Cooling Coil – Performance Characteristic



more suited for USA

This coil characteristic is therefore based on

- Inlet water = 7.2 °C
- Outlet water = 12.8 °C



This coil characteristic

more suited for Our Region

Fig 1.4b. Cooling coil working under following condition:

Water: 6 °C inlet / 12 to 24 °C return

Air: 24 °C inlet / 16 to 24 °C outlet

Terminal. Control valve. BAS

- ❖ 유량과 차압 관계
- ❖ Coil 성능특성(ASHRAE 90.1)
- ❖ **Valve 성능 특성**
- ❖ Terminal 과 Valve의 관계
- ❖ Control Valve의 **Authority**
- ❖ PIBCV

밸브의 특성(ASHRAE-Fundamentals)

ASHRAE – Fundamentals of HVAC Control

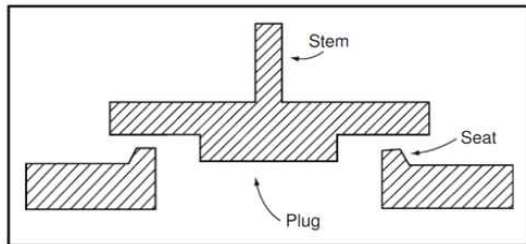


Figure 3-7 Quick-opening (Flat Plate) Valve Plug

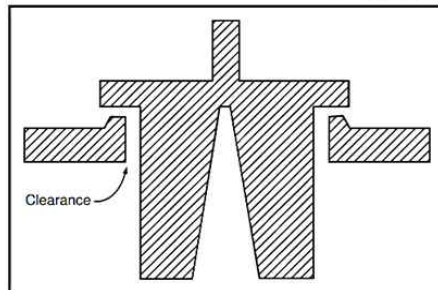


Figure 3-5 Linear (V-Port) Valve Plug

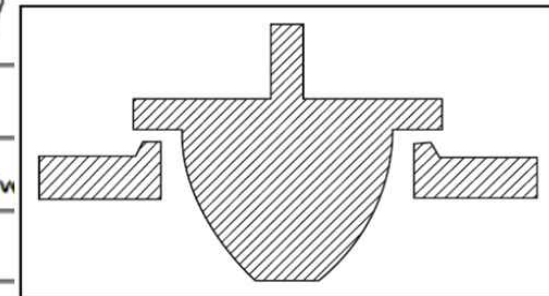


Figure 3-6 Equal Percentage Valve Plug

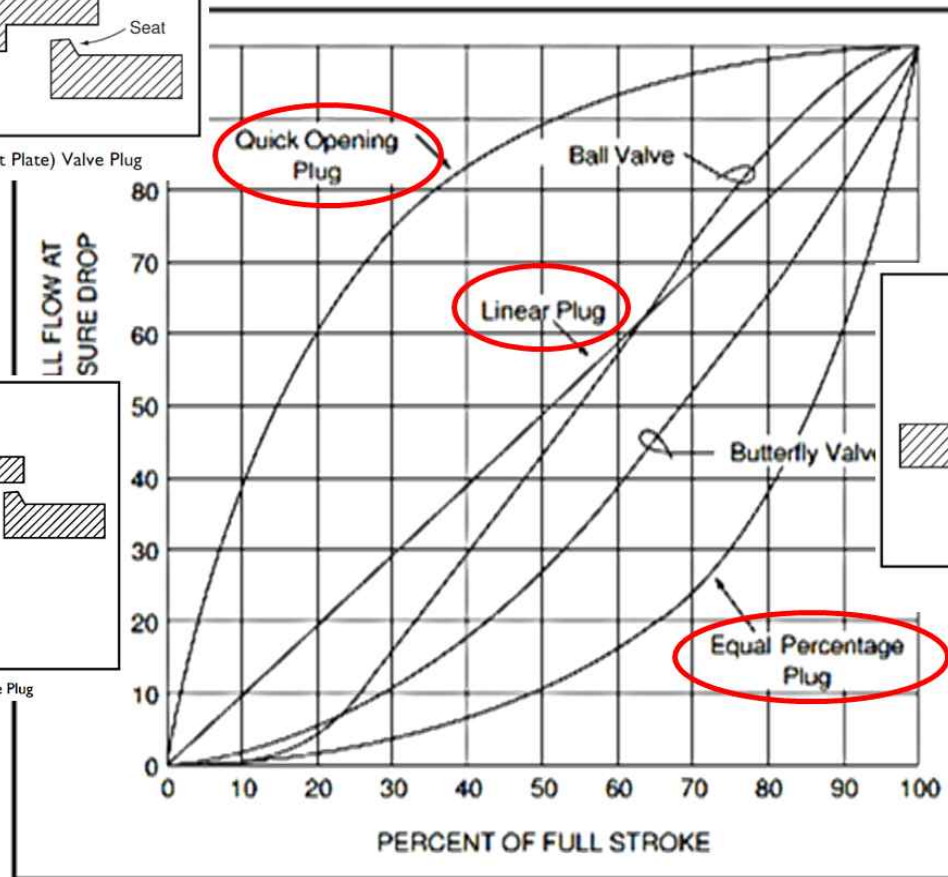


Figure 3-10 Typical Valve Characteristics at Constant Pressure Drop

Terminal. Control valve. BAS

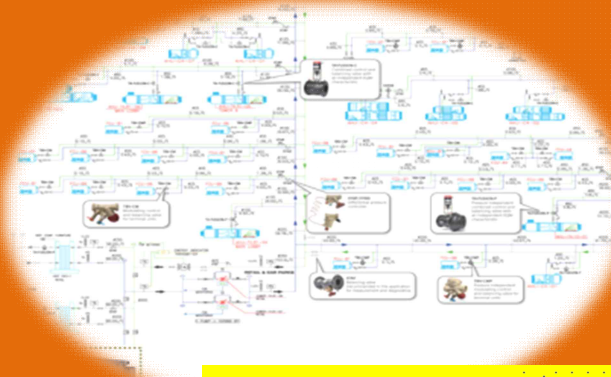
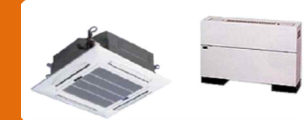
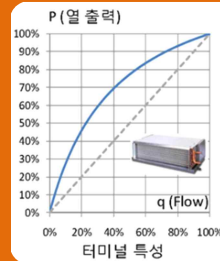
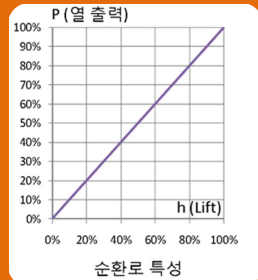
- ❖ 유량과 차압 관계
 - ❖ Coil 성능특성(ASHRAE 90.1)
 - ❖ Valve 성능 특성
- Terminal 과 Valve의 관계
- ❖ Control Valve의 **Authority**
 - ❖ PIBCV

Terminal과 Valve의 관계 (Energy)

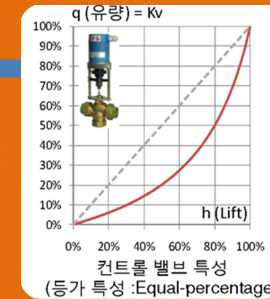
열원을 설계 부하량으로 각 사용처에 공급



BEMS



Hydronic Engineering(분배공학)



설계부하대로 부분부하시 최적의 유량을 제어 및 현수온도 $\Delta t 5^{\circ}\text{C}$ 이상 유지

EQM특성 Valve 사용
Control Valve Authority 0.25(Good) 이상
KVs 값을 조정 할 수 있는 Valve 적용
Control Valve Rangeability 100% 사용



$$\Delta p \propto q^2$$



열원 생산: 냉수 7°C, 온수 70°C

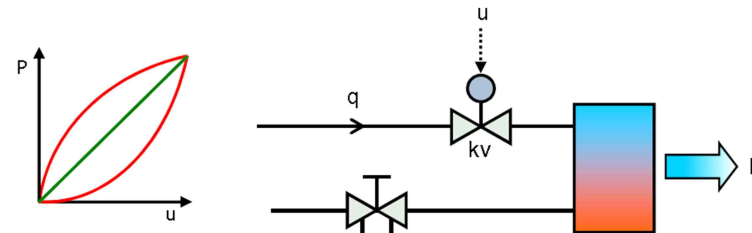
열원을 사용처까지 수송

터미널, 컨트롤 Valve, BAS의 연관 관계 (ASHRAE 90.1)

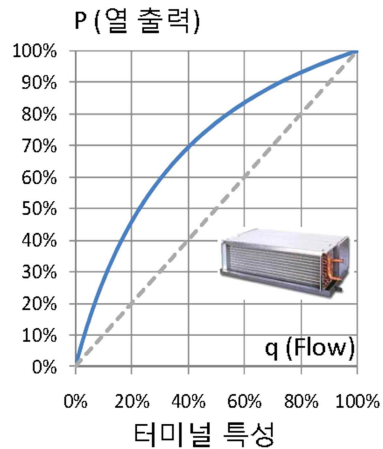
- 안정적이고 정확한 BAS 제어를 얻기 위해서는, 제어 시스템이 비례적인 움직임(선형 특성)이어야 한다.
- 냉난방 코일 성능 특성은 결코 선형적이지 않다
- 안정적이고 정확한 제어를 위해 터미널 유닛 특성의 비선형은 모든 선형 순환로 특성을 보장 하기 위해 컨트롤 밸브의 수정 등가특성(EQM)에 의해 보상되어진다.

비례 제어 터미널 특성과 컨트롤 밸브 특성

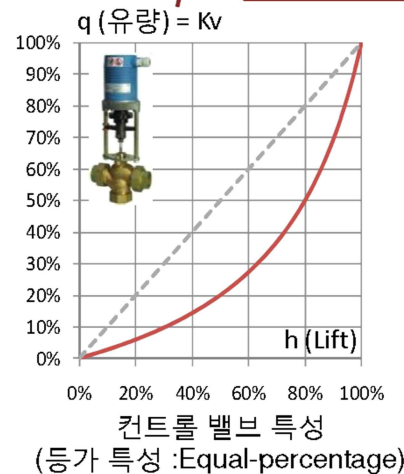
가능한 선형적인 순환로 특성을 얻기 위해, 터미널 특성의 비선형성은 컨트롤 밸브의 등가 특성으로 보상되어진다.



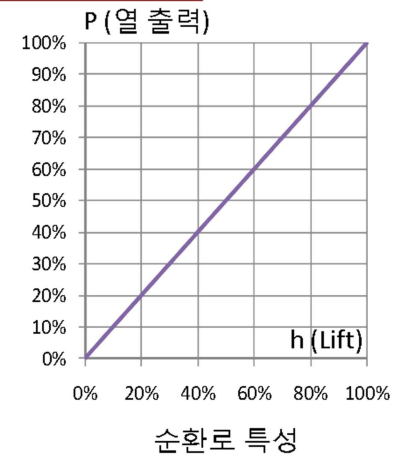
Δp 가 일정한 경우에만:
 $q = K_v \sqrt{\Delta p}$



+



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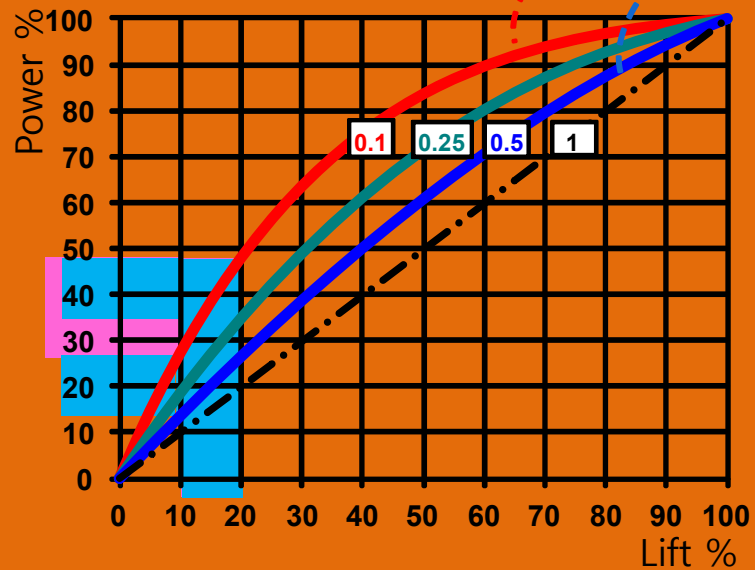
Terminal. Control valve. BAS

- ❖ 유량과 차압 관계
- ❖ Coil 성능특성(ASHRAE 90.1)
- ❖ Valve 성능 특성
- ❖ Terminal 과 Valve의 관계
- ❖ Control Valve의 **Authority**
- ❖ PIBCV

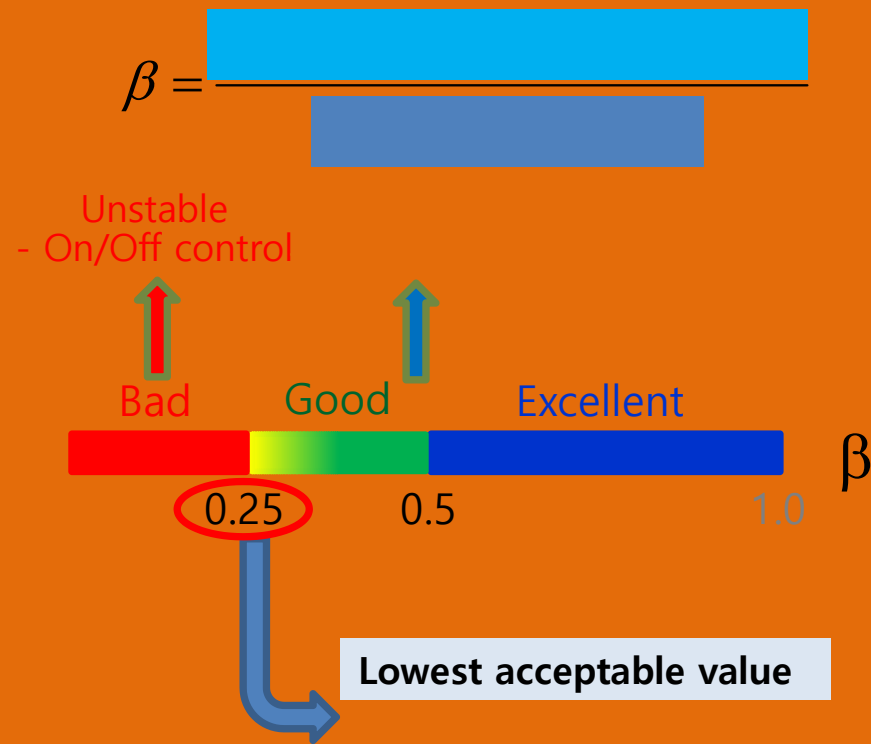
Control Valve Authority Guidelines

The "lower" the valve authority, the larger the dP variation on the control valve. the larger the distortion on the valve characteristic.

The "higher" the valve authority, the smaller the Dp variation and the smaller the distortion



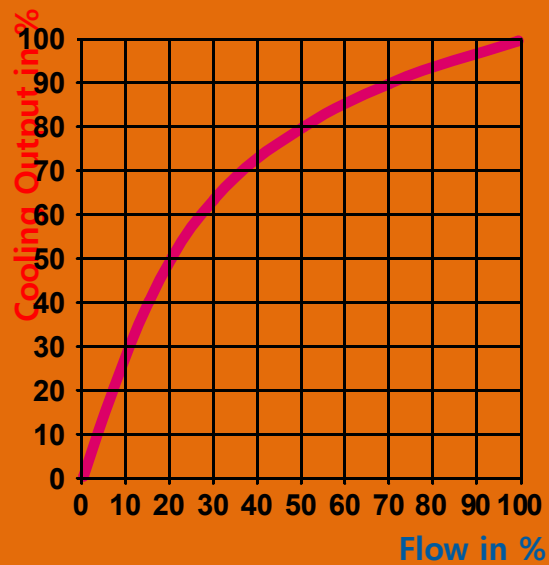
Control valve with EQM Characteristic



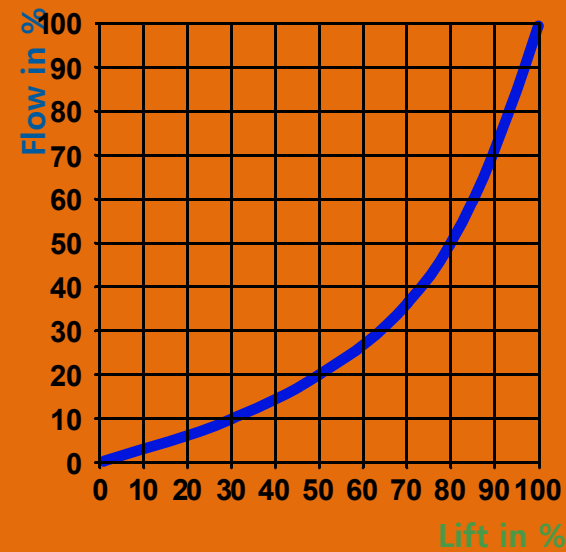
Hydronic design(Terminal과 Valve의 관계)

What is this?

- “Combined” performance of 2 characteristics:
 1. “AHU/FCU” performance characteristic (cooling output vs flow)
 2. “Control valve” performance characteristic (flow vs valve lift)



“AHU/FCU” characteristic

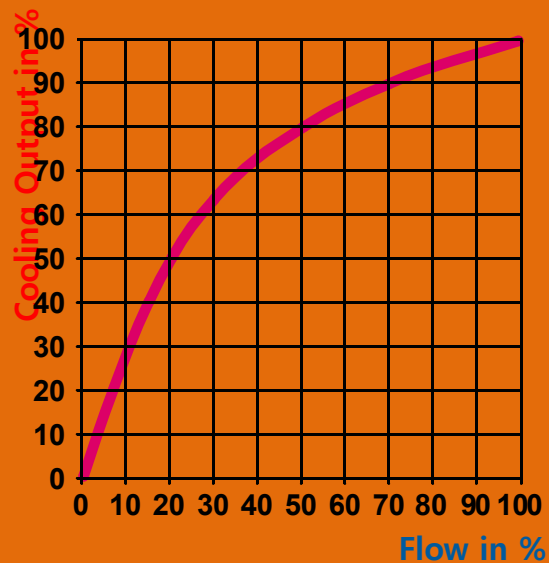


“Control valve” characteristic

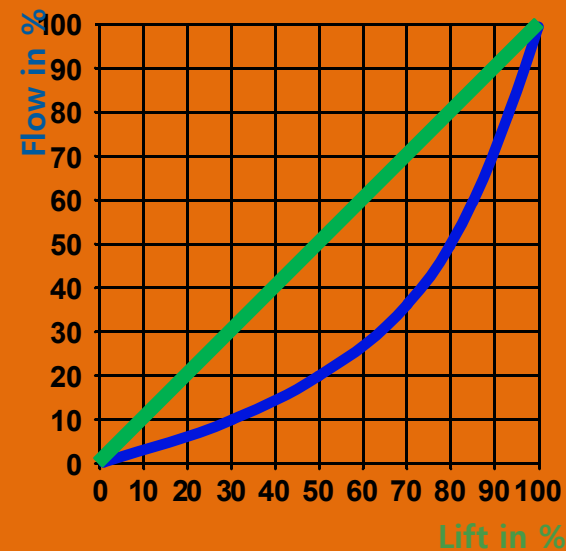
Global Circuit Characteristic

What is this?

- “Combined” performance of 2 characteristics:
 1. “AHU/FCU” performance characteristic (cooling output vs flow)
 2. “Control valve” performance characteristic (flow vs valve lift)



“AHU/FCU” characteristic



“Control valve” characteristic

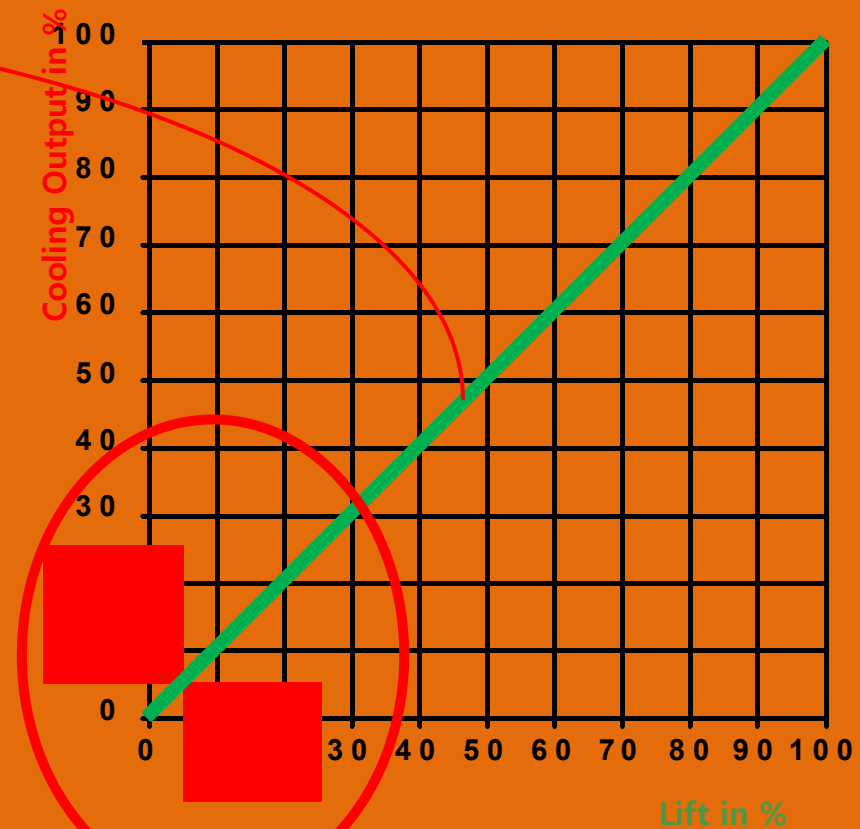
Global Circuit Characteristic

- What is the "ideal" global characteristic?
 - Linear
- Why?

Cooling Power Lift

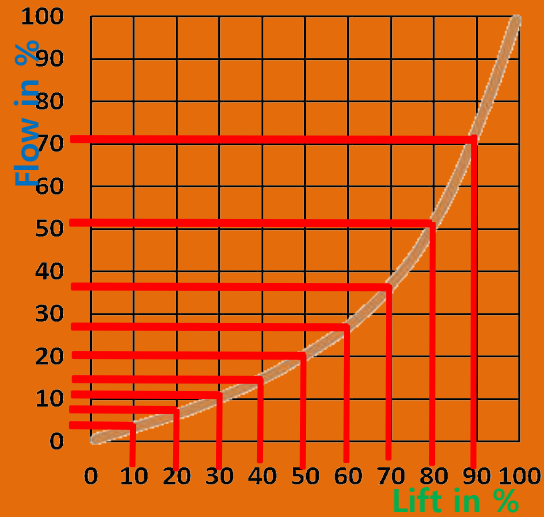
100%	100%
90%	90%
80%	80%
70%	70%
60%	60%
50%	50%
40%	40%
30%	30%
20%	20%
10%	10%
0%	0%

Stable control of temperature
No overflow
No underflow
Best for BAS

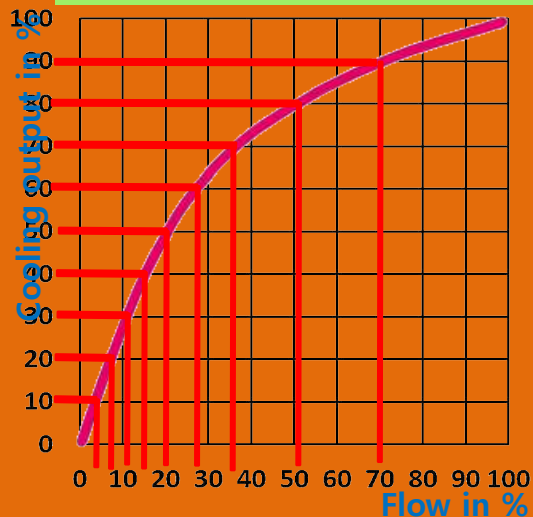


"Global circuit" characteristic

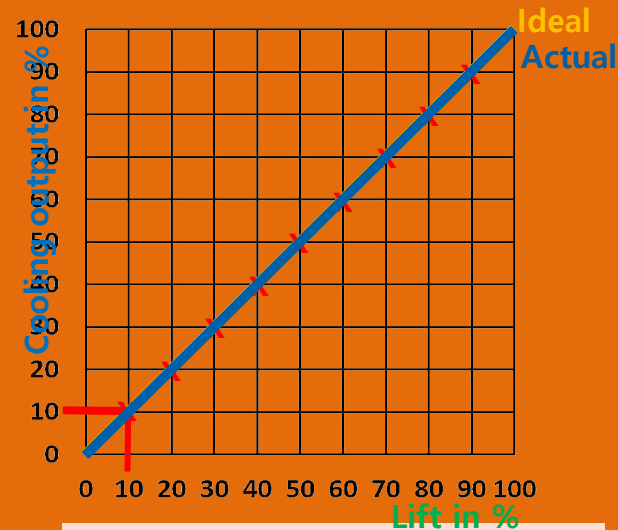
Good Valve Authority



Control Valve (EQM) Characteristic



AHU/FCU Characteristic



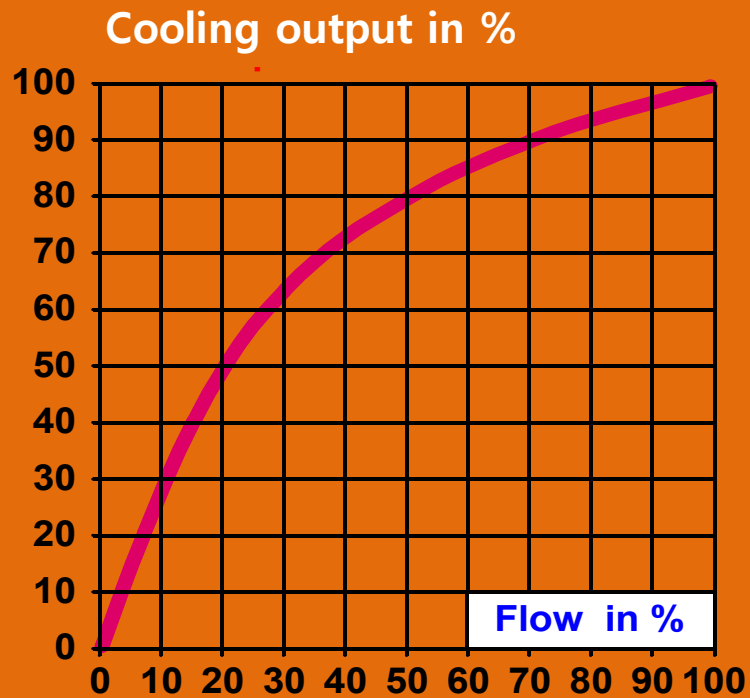
Global Characteristic - EQM Valve

EQM valve is exact match and therefore gives the "ideal" Global Characteristic suitable for HVAC control

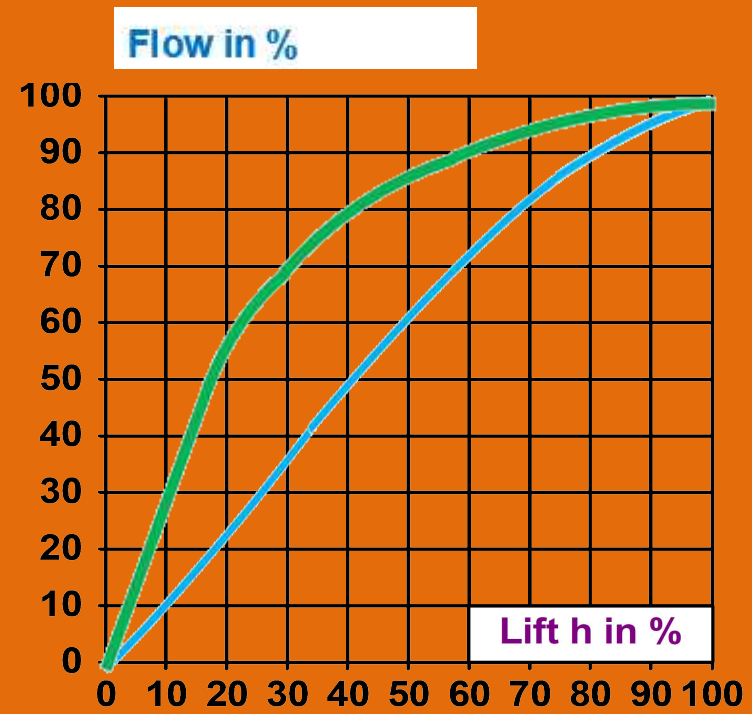
2 options available to achieve close to 100% authority

- Independent 'differential pressure controllers' on each circuit
- Adjustable KVs control valve with fixed EQM characteristic

Bad Valve Authority

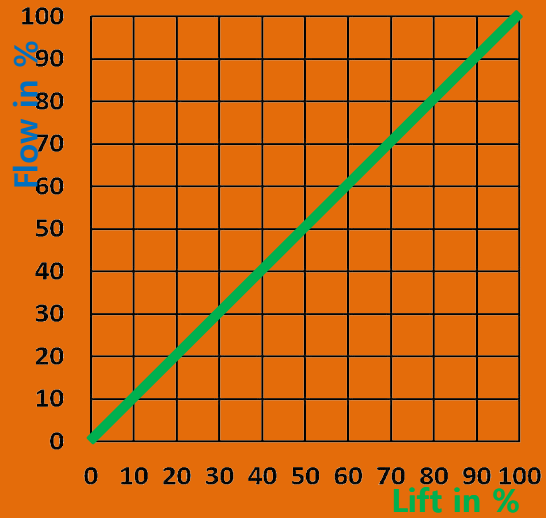


Terminal unit characteristic

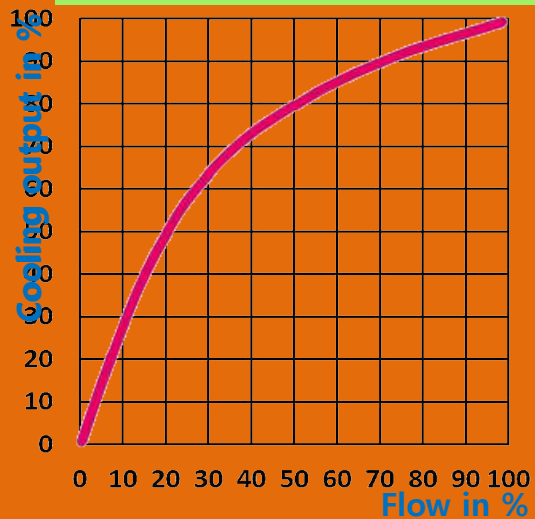


Resultant characteristic

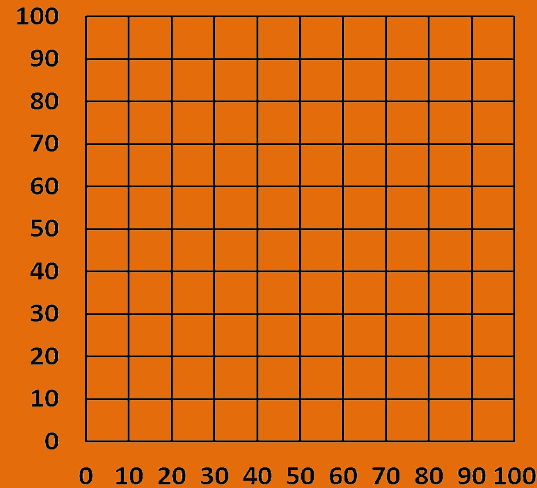
Linear Valve with 100% Authority



Control Valve (Linear) Characteristic

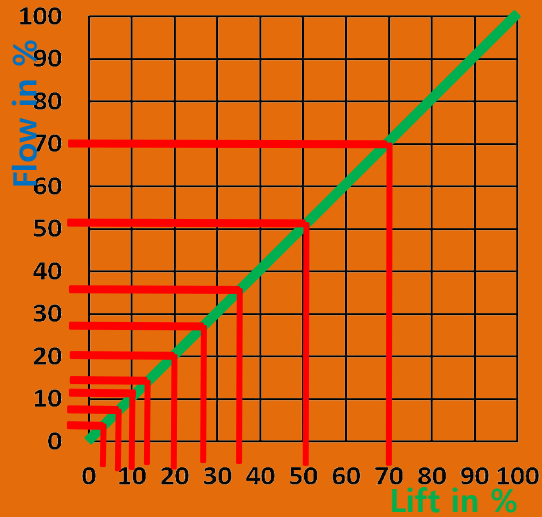


AHU/FCU Characteristic

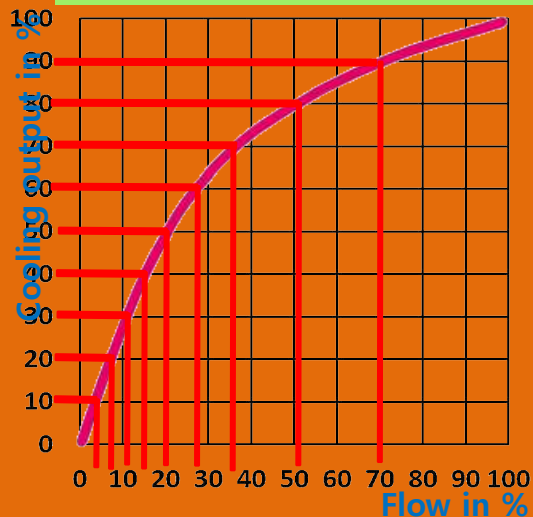


Global Characteristic - Linear Valve

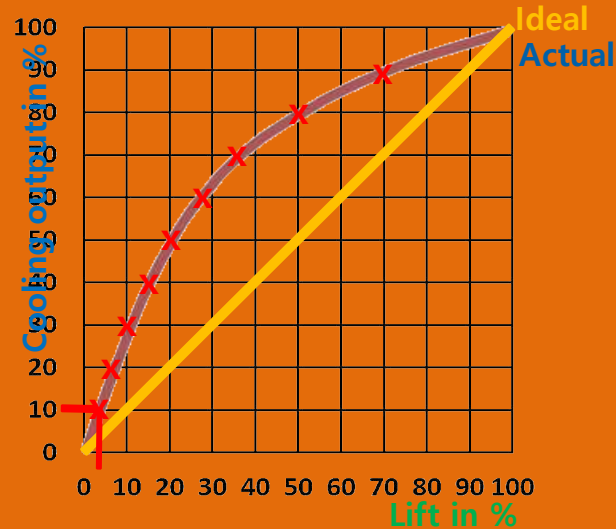
Linear Valve with 100% Authority



Control Valve (Linear) Characteristic



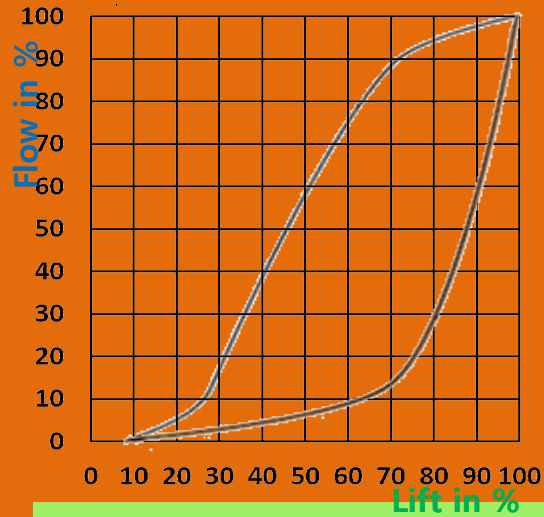
AHU/FCU Characteristic



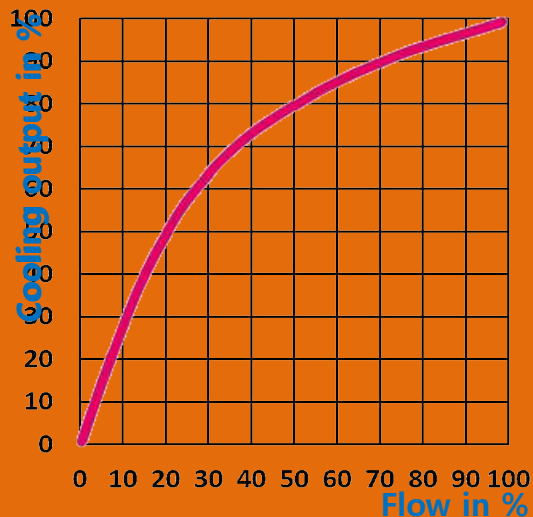
Global Characteristic - Linear Valve

Linear valve only suitable for ON/OFF moderate response systems (HVAC control)

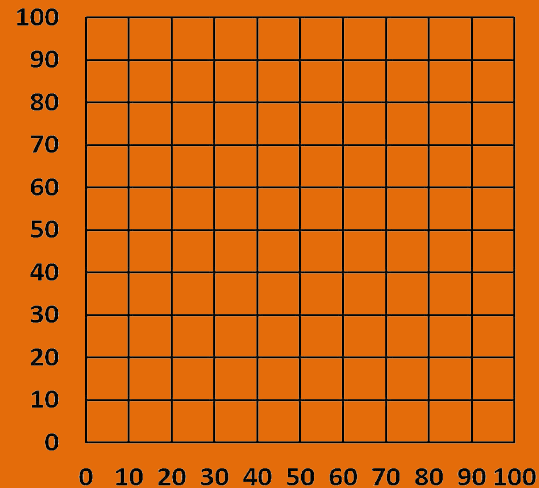
Characterised Ball Valve with 100% Authority



Control Valve (Characterised Ball) Characteristic

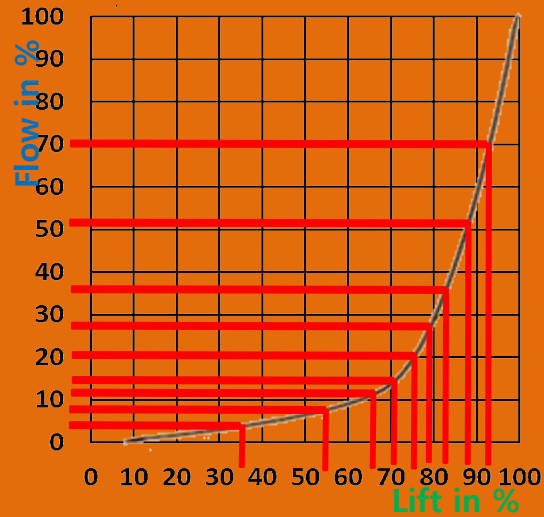


AHU/FCU Characteristic

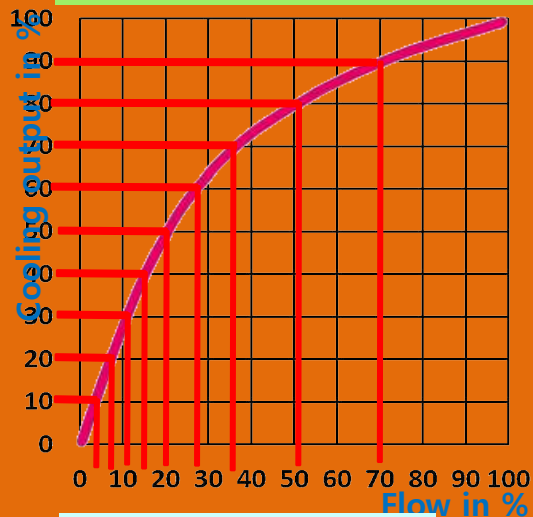


Global Characteristic - Characterised Ball Valve

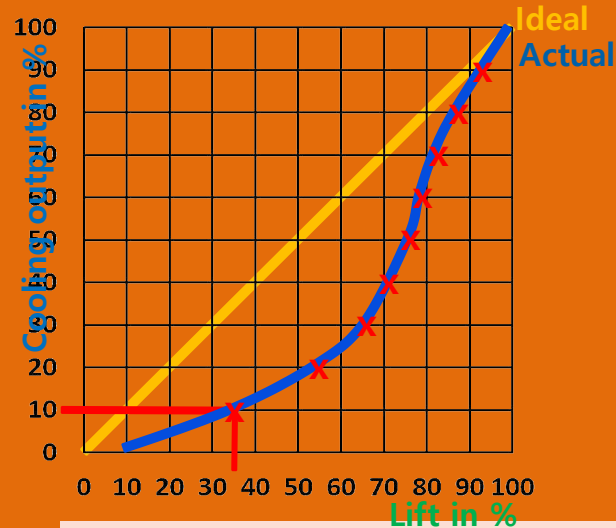
Characterised Ball Valve with 100% Authority



Control Valve (Characterised Ball) Characteristic



AHU/FCU Characteristic



Global Characteristic - Characterised Ball Valve

i.e. if ΔP is constant
But ePIV does not keep ΔP constant

Energy Valve - ePIV

Extract from write-up:

- *Characterized Control Valve (CCV) Technology*
- *2-way characterized control valve*

What does this mean?

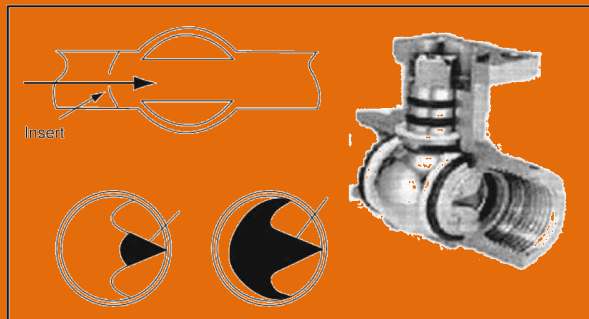
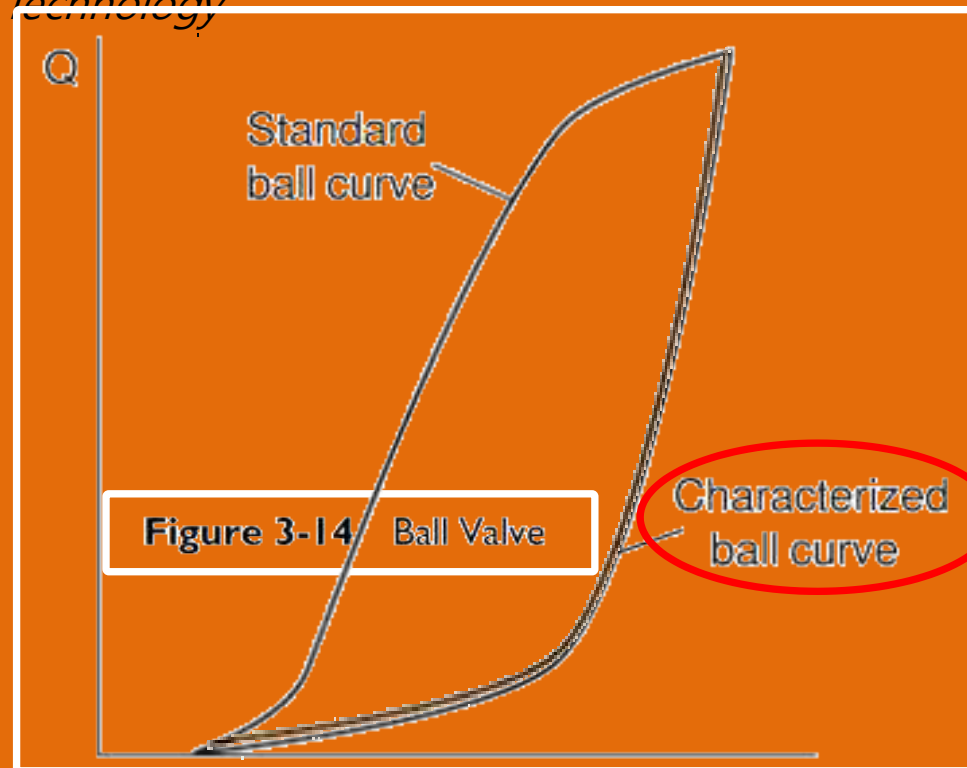
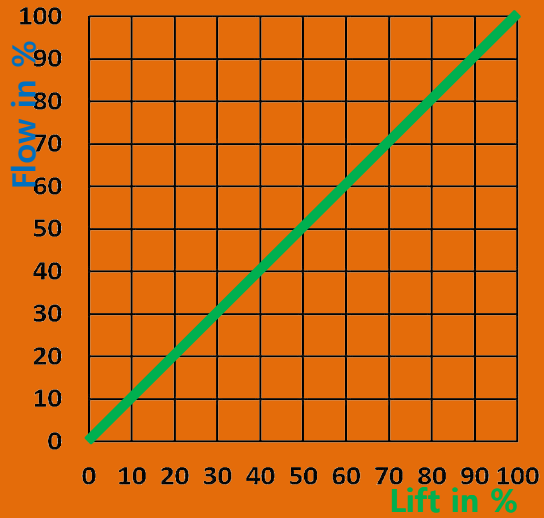


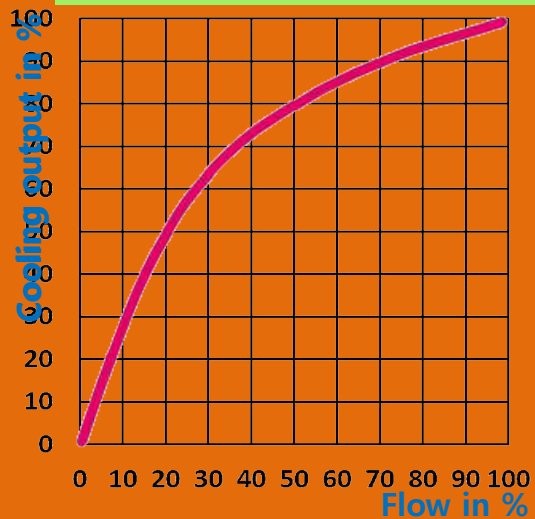
Figure 3-13



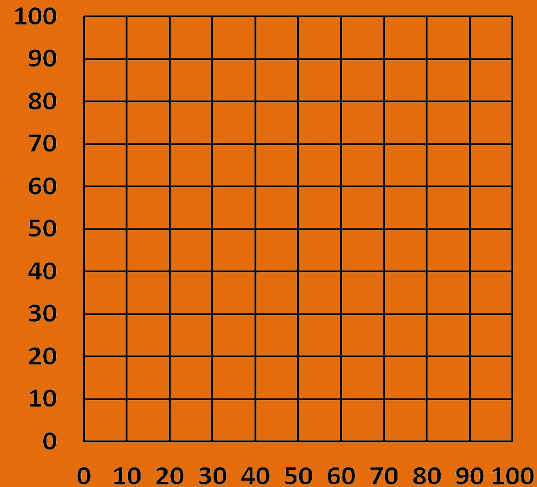
Linear Valve with 100% Authority



Control Valve (Linear) Characteristic

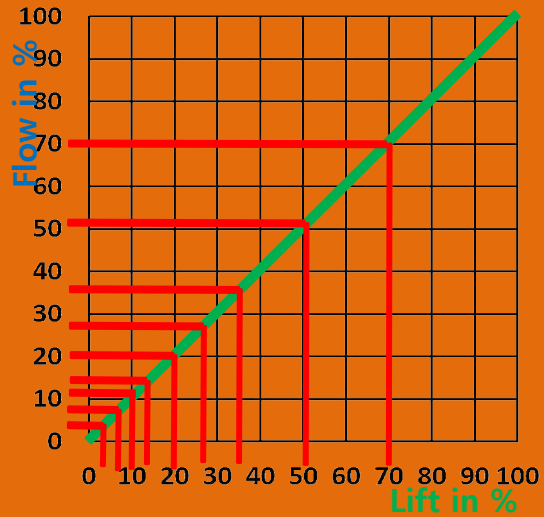


AHU/FCU Characteristic

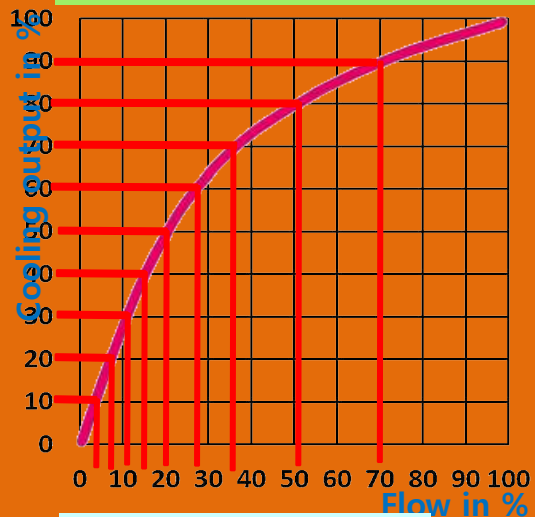


Global Characteristic - Linear Valve

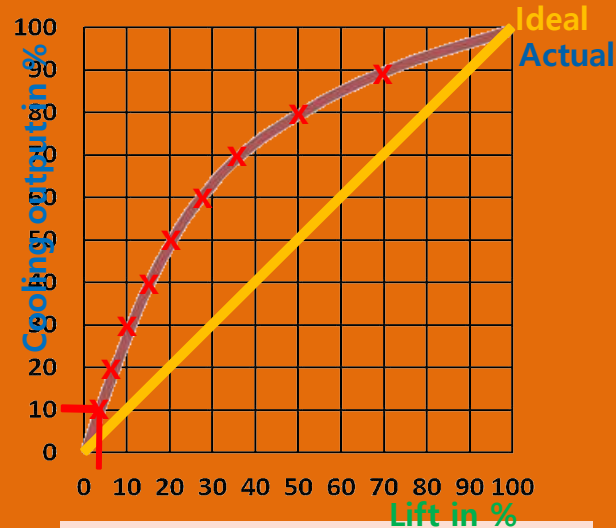
Linear Valve with 100% Authority



Control Valve (Linear) Characteristic



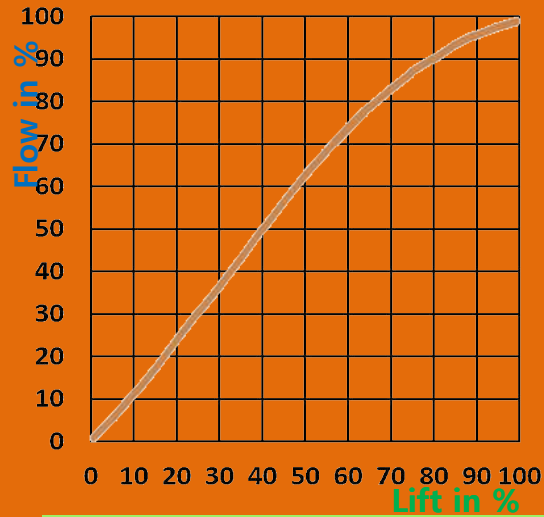
AHU/FCU Characteristic



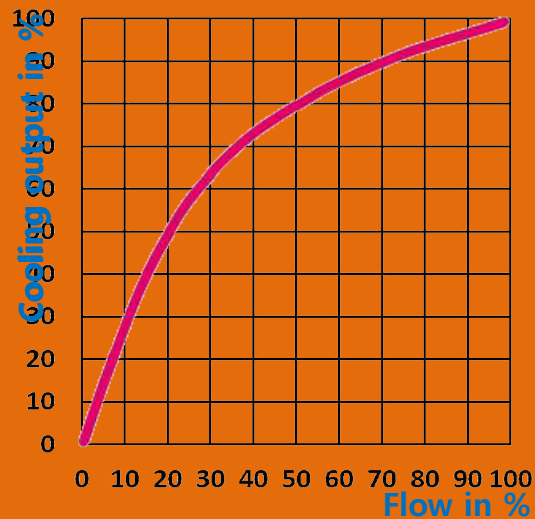
Global Characteristic - Linear Valve

Linear valve only suitable for ON/OFF moderate response systems (HVAC control)

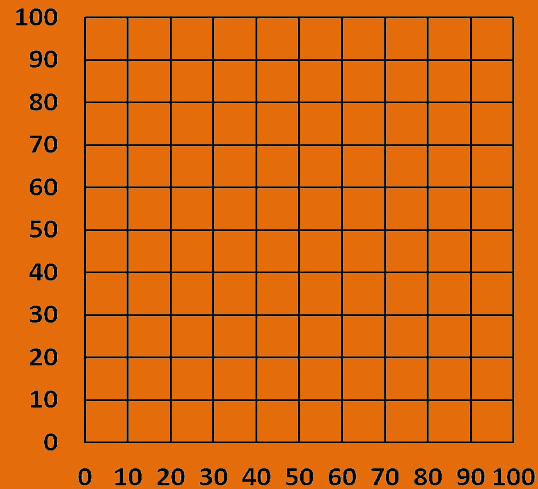
EQM Valve with Poor Authority



Control Valve (EQM - 0.1 Authority) Characteristic

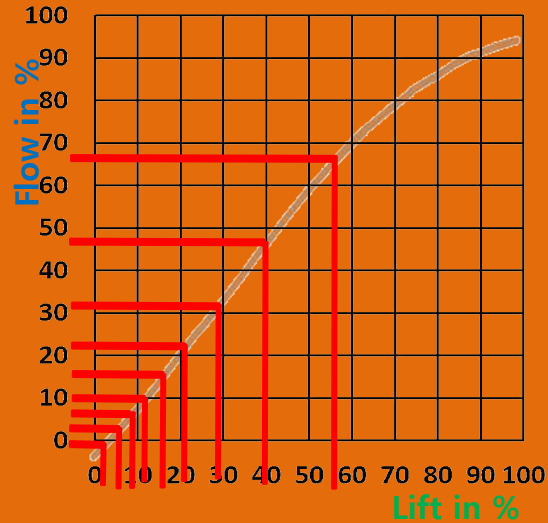


AHU/FCU Characteristic

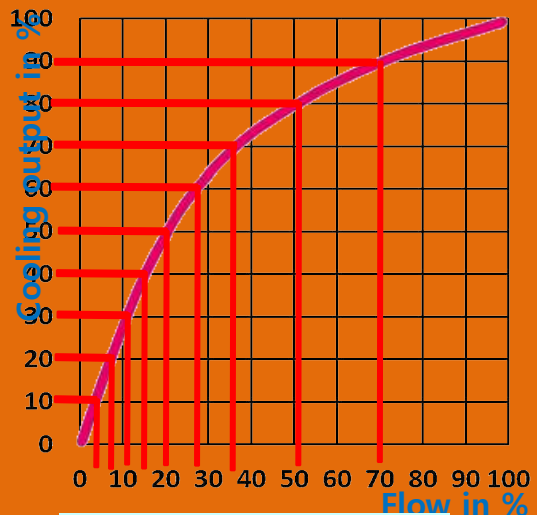


Global Characteristic - EQM Valve with 0.1 Authority

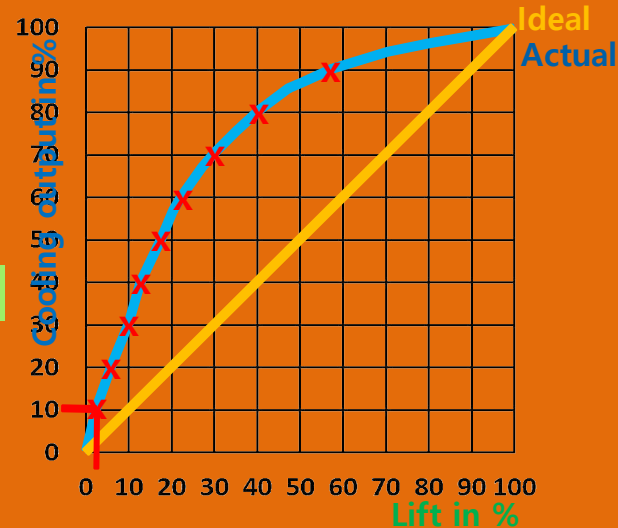
EQM Valve with Poor Authority



Control Valve (EQM – 0.1 Authority) Characteristic



AHU/FCU Characteristic

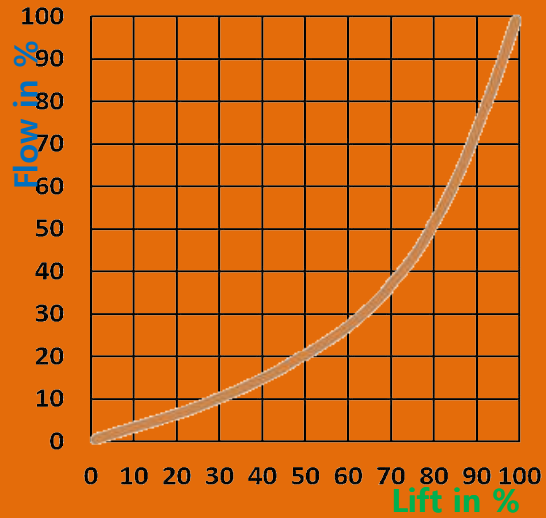


Global Characteristic – EQM Valve with 0.1 Authority

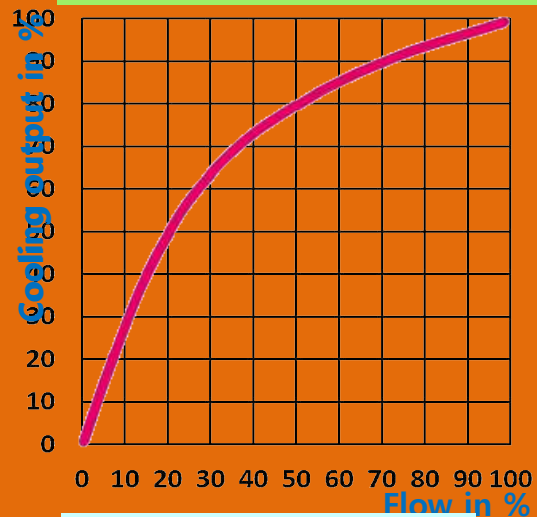
EQM valve with 0.1 Authority due to:

- Control valve is oversized, not calculated but uses a factor based on pipe size
- No differential pressure controller installed
- Pump head higher than required, no hydronic calculation

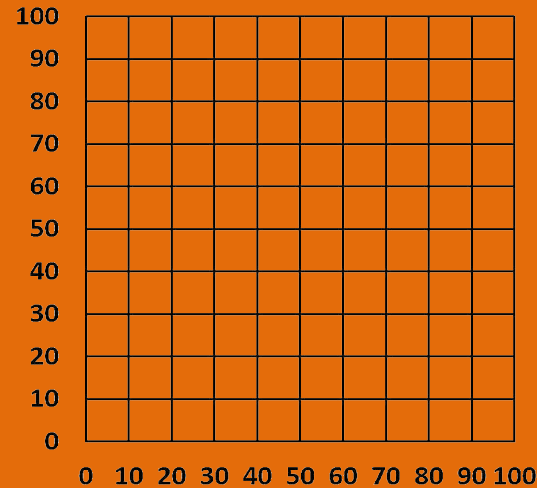
EQM Valve with 100% Authority



Control Valve (EQM) Characteristic

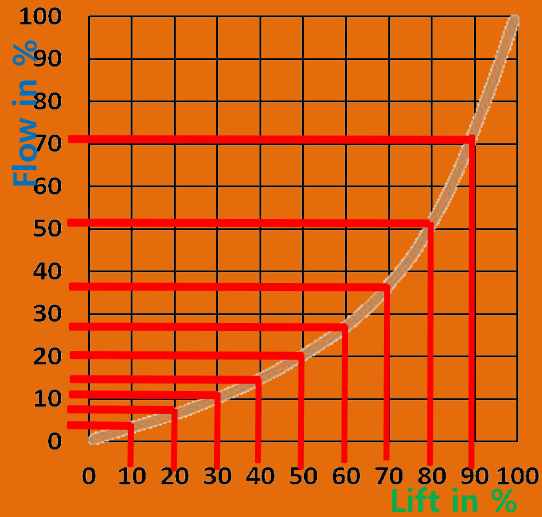


AHU/FCU Characteristic

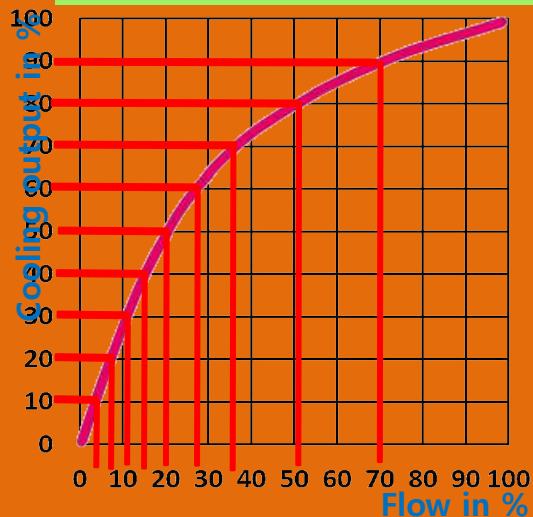


Global Characteristic - EQM Valve

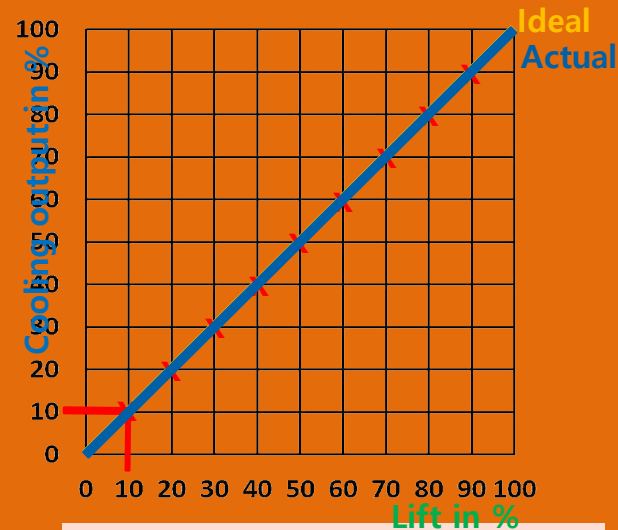
EQM Valve with 100% Authority



Control Valve (EQM) Characteristic



AHU/FCU Characteristic



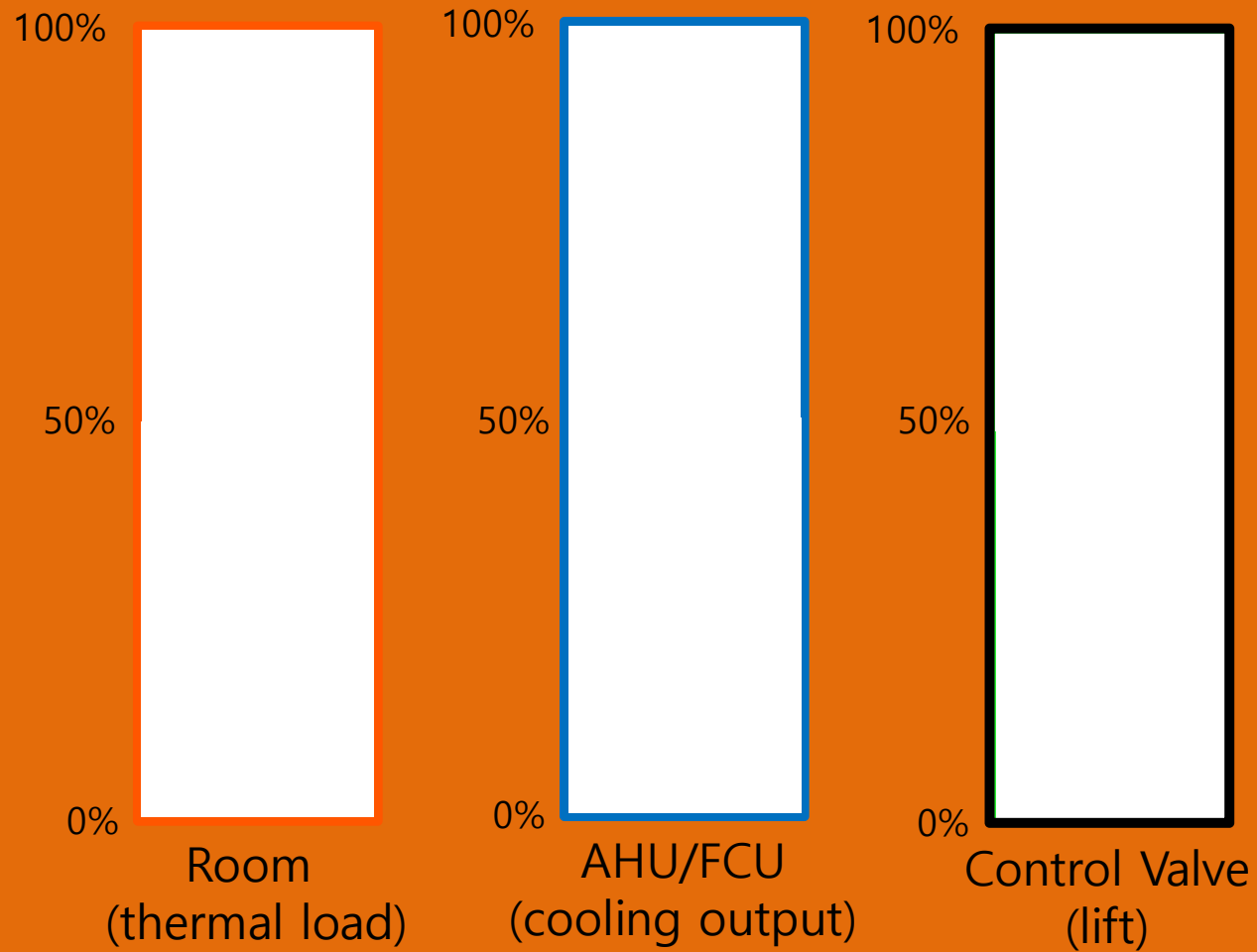
Global Characteristic - EQM Valve

EQM valve is exact match and therefore gives the "ideal" Global Characteristic suitable for HVAC control

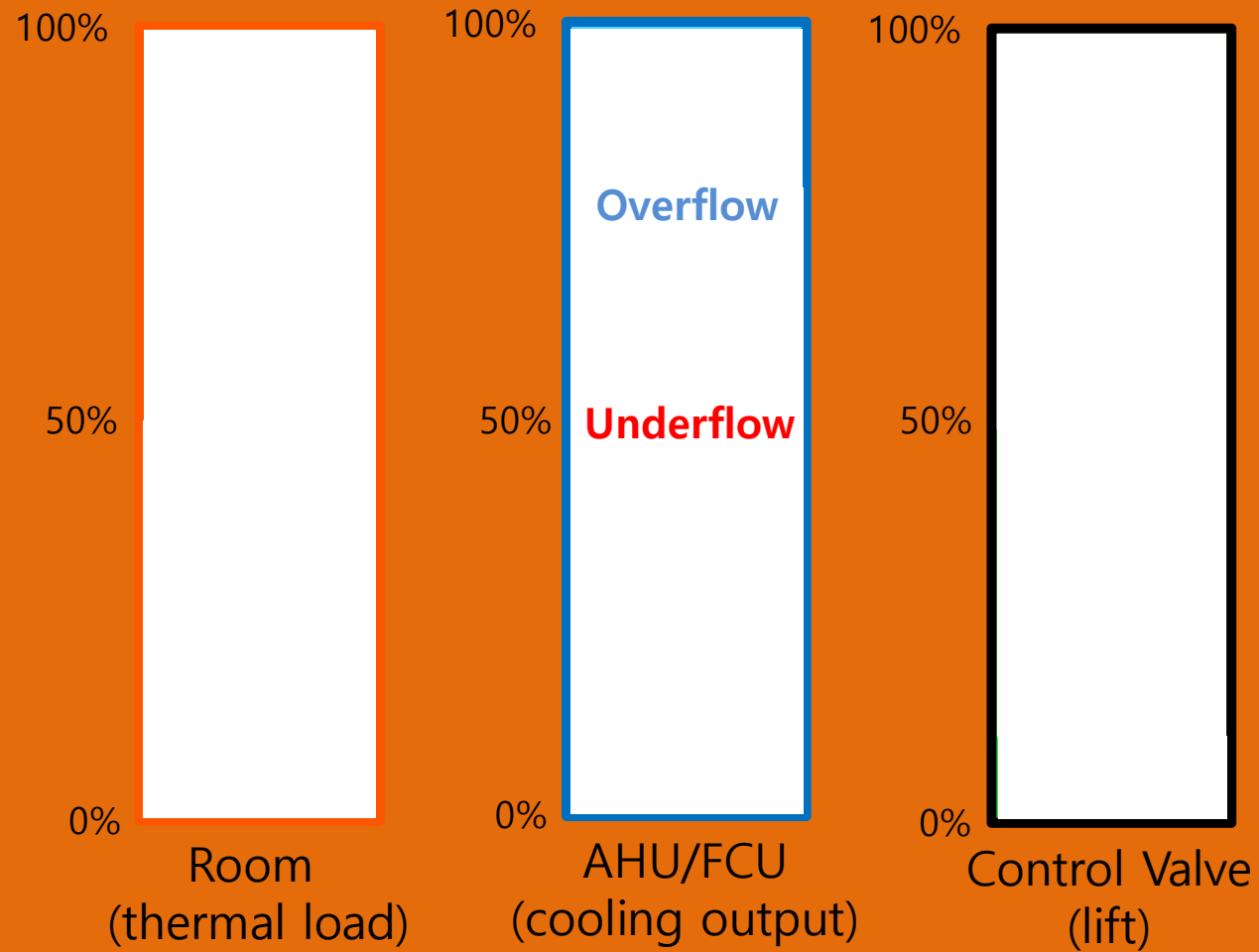
2 options available to achieve close to 100% authority

- Independent 'differential pressure controllers' on each circuit
- Adjustable KVs control valve with fixed EQM characteristic

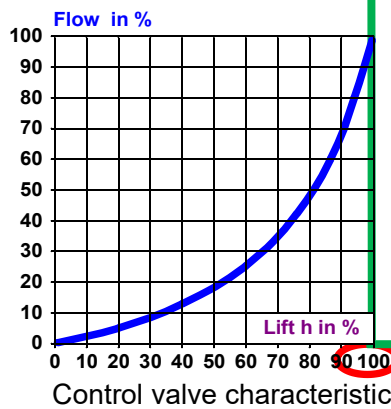
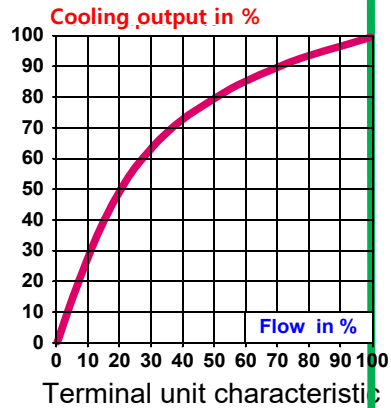
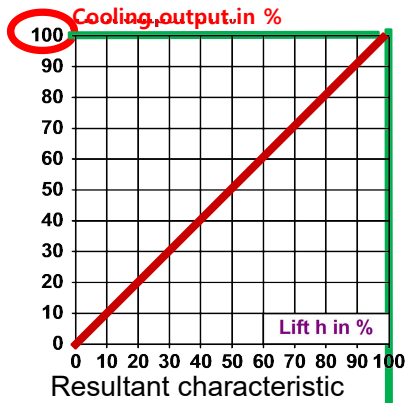
"Good" Authority Valve



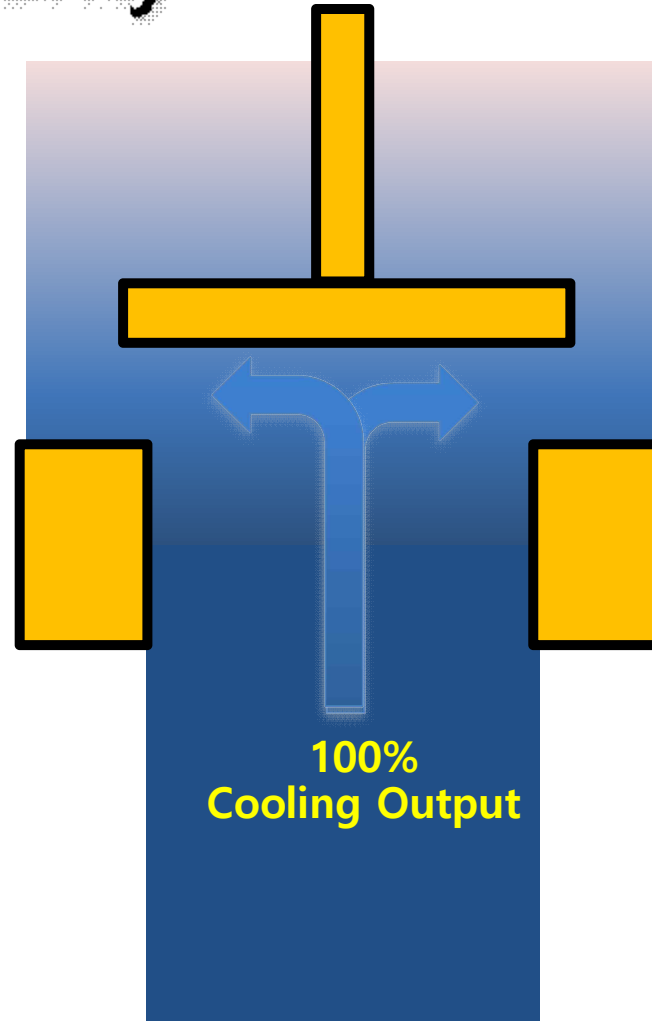
"Bad" Authority Valve



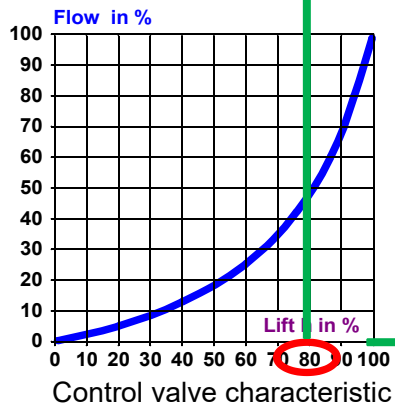
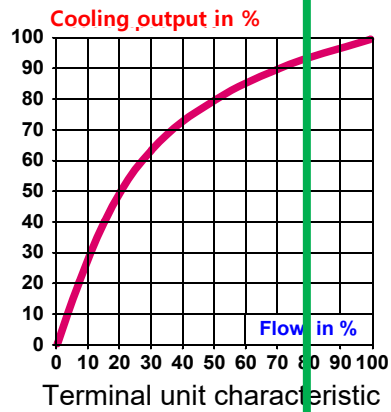
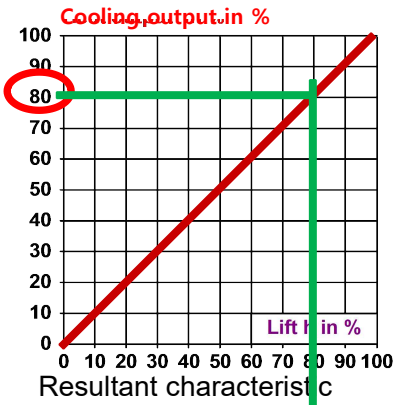
Good Valve Authority



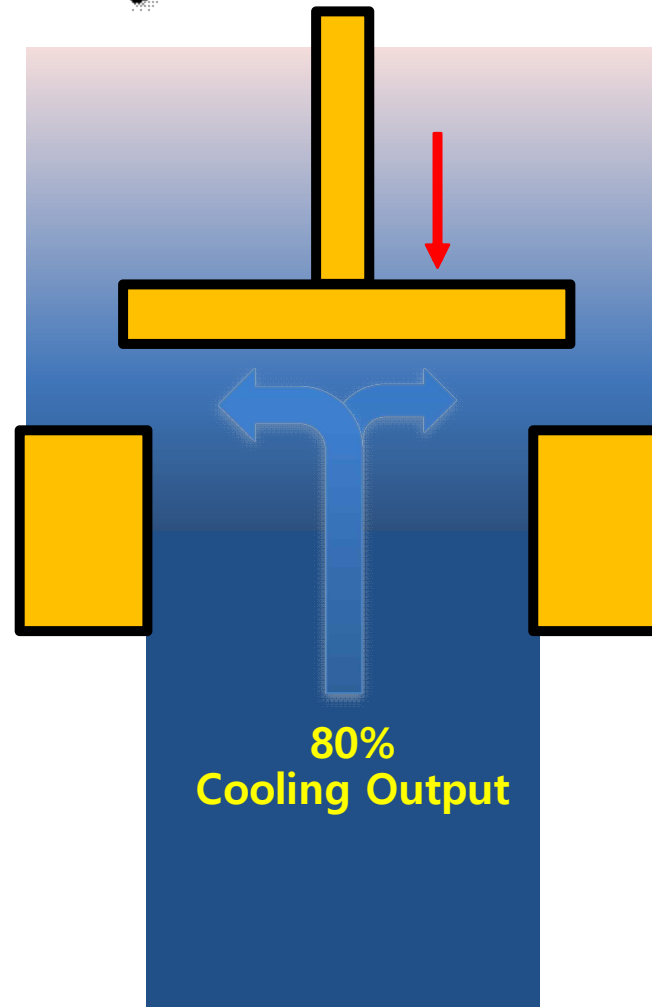
100% Opening



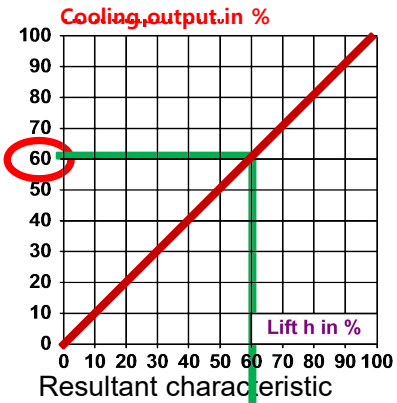
Good Valve Authority



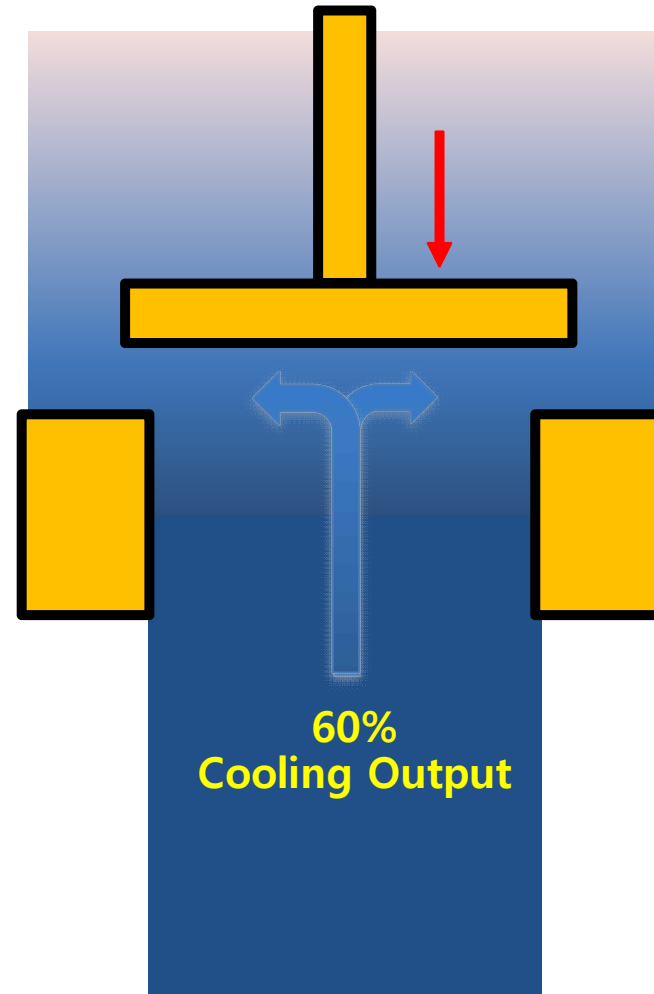
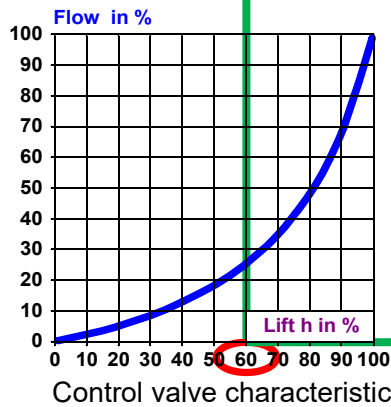
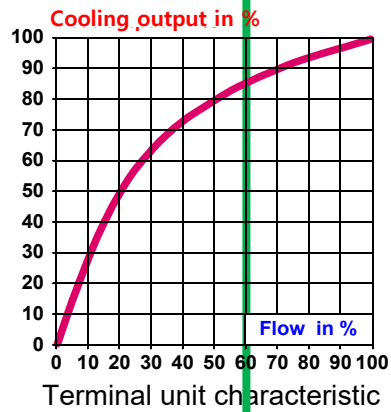
80% Opening



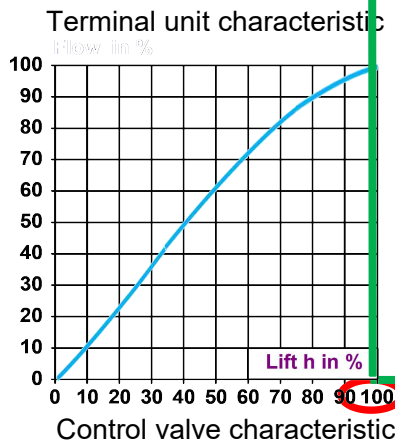
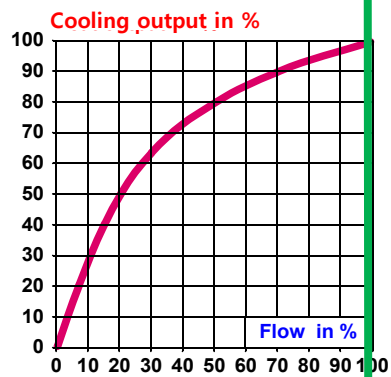
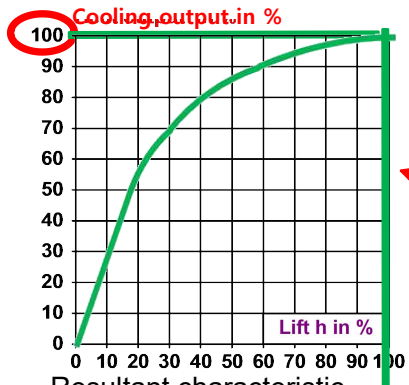
Good Valve Authority



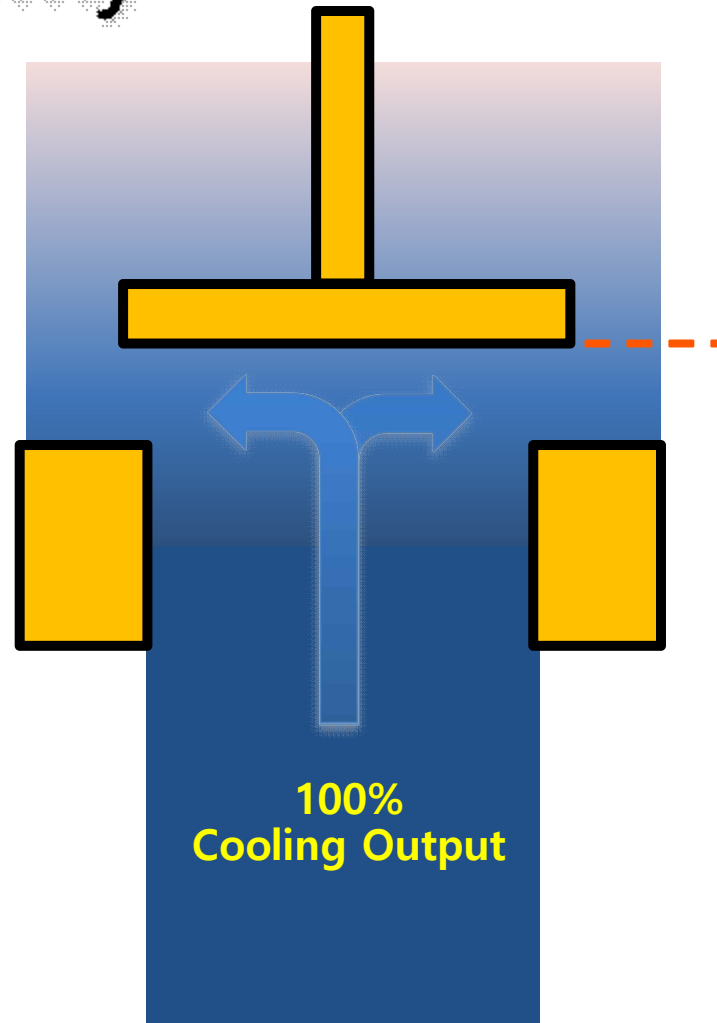
60% Opening



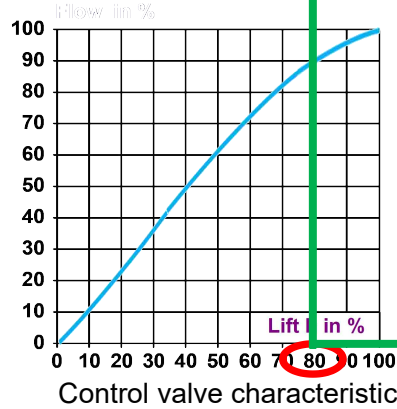
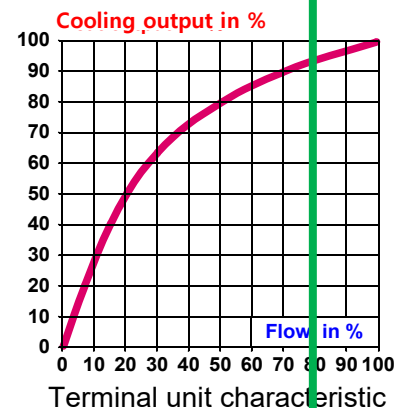
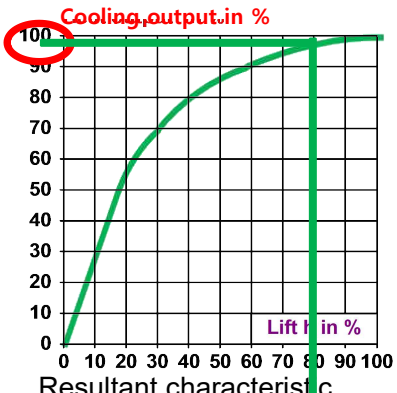
Bad Valve Authority



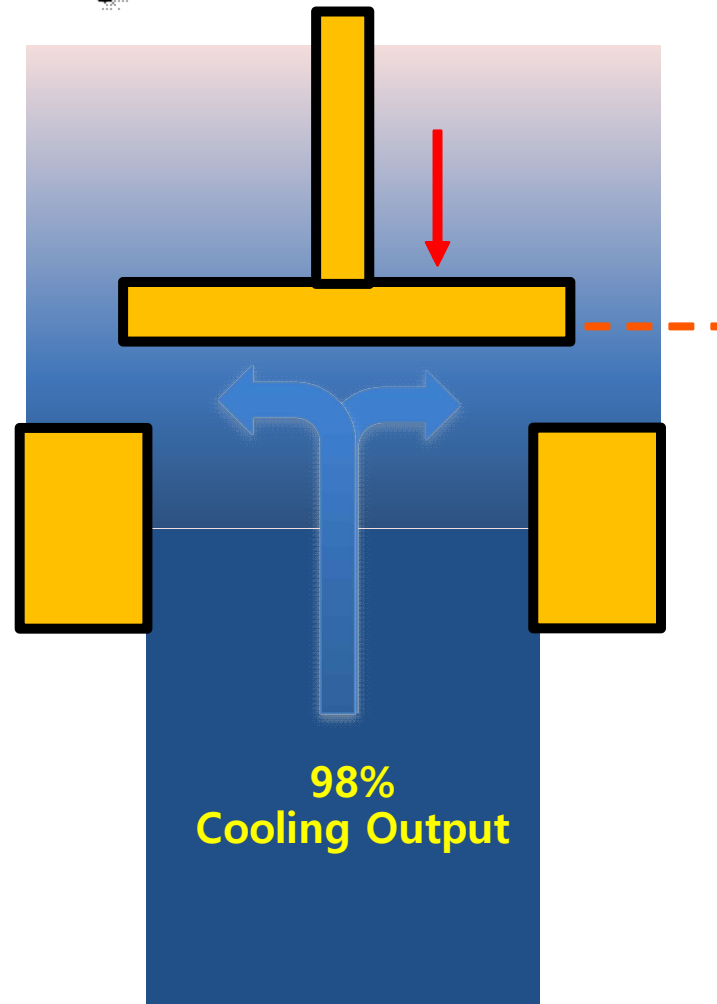
100% Opening



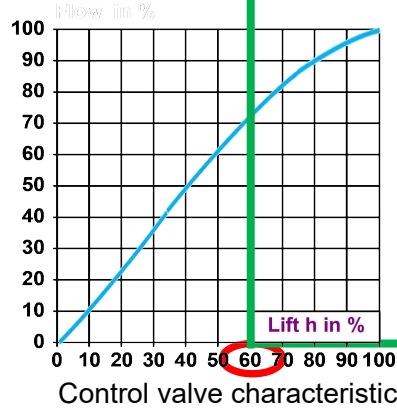
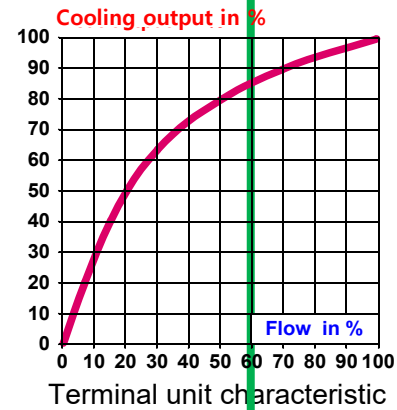
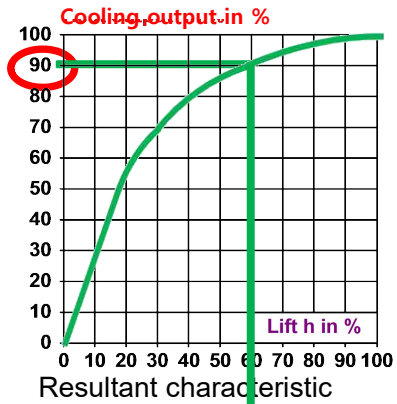
Bad Valve Authority



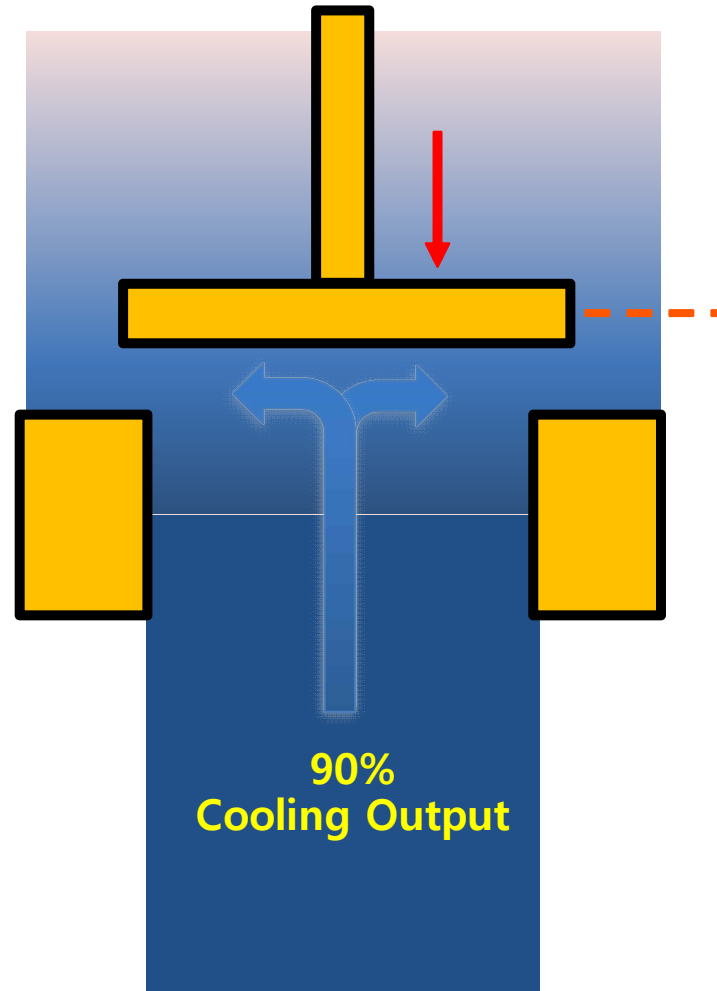
80% Opening



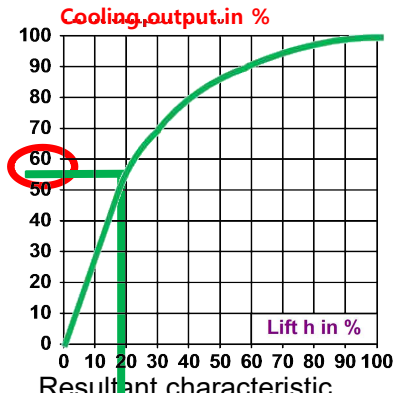
Bad Valve Authority



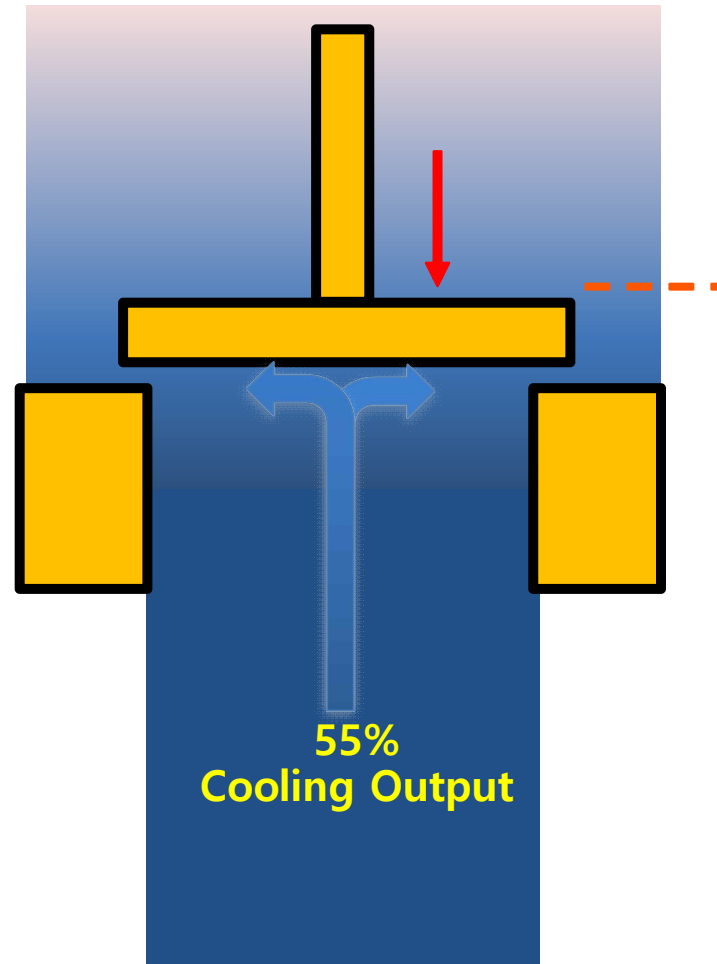
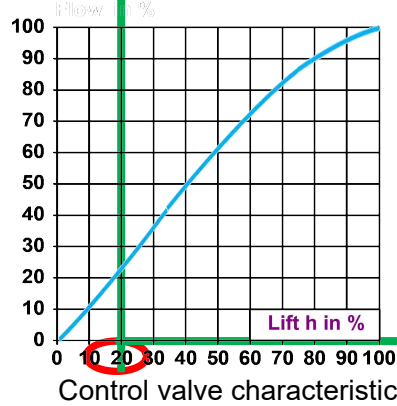
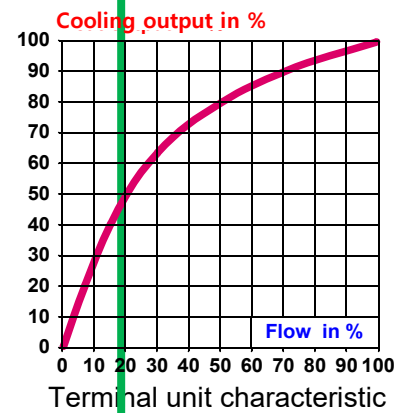
60% Opening



Bad Valve Authority



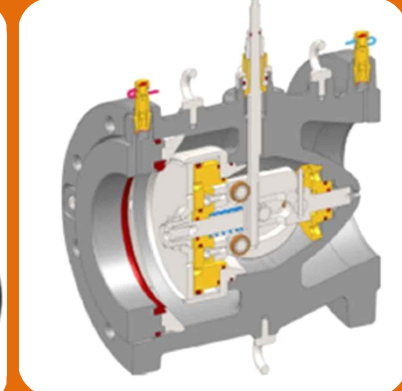
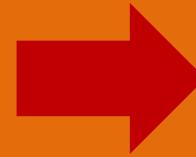
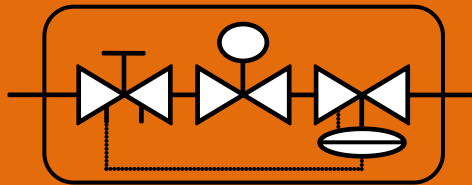
20% Opening



Terminal. Control valve. BAS

- ❖ 유량과 차압 관계
- ❖ Coil 성능특성(ASHRAE 90.1)
- ❖ Valve 성능 특성
- ❖ Authority
- ❖ **PIBCV**

압력 독립 밸런싱 컨트롤 밸브 (Pressure Independent Balancing Control valve)



- ✓ 조정 가능한 Kvs
- ✓ 독립적인 EQM 특성
- ✓ 탁월한 부하 조정비 (Rangeability)

- 3가지 기능(밸런싱, 컨트롤, 차압 컨트롤)이 한개 밸브에 모두 포함되어 있다.
- 이러한 밸브 종류에 대해서, 여러 명칭이 사용된다 :
 - 압력 독립 밸런싱 컨트롤 밸브 (PIBCV)
 - (Pressure Independent Balancing and Control Valve)
 - (이 기능의 제품에 대한 TA의 공식적인 명칭)
 - ... 그러나 또한 다음의 여러 명칭의 이름을 보게 된다.
 - 복합 밸브
 - 유량과 온도 컨트롤러
 - 컨트롤과 밸런싱 밸브...