Natural Ventilation Study

for the proposed development known as

Macquarie Place, Parramatta

July 26, 2011

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Table of Contents

1.0 Executive Summary

This report presents the results of a detailed investigation into the natural ventilation performance of the residential apartments of the proposed development known as Macquarie Place, located in Parramatta.

Testing was performed using Windtech's boundary layer wind tunnel facility, which has a 2.6m wide working section and has a fetch length of 14m. Measurements were carried out using a 1:300 scale model of the development. The study model has been constructed based on architectural drawings prepared by the project architect Allen Jack + Cottier, received July 7, 2011. The proximity model extends to a radius of approximately 375m from the centre of the subject site and includes all of the significant surrounding buildings and topographical effects.

The model of the proposed development was fitted with a total of 318 pressure taps (sensors) measuring the pressure coefficients at each of the opening locations to the residential units of the two buildings. A total of 272 different internal flow path pairings have been considered for the residential units of the two buildings for this study.

Pressure coefficient measurements are made in the wind tunnel for 36 wind directions, at 10 degree increments and converted to 16 wind directions for this study. The reference wind climate data used in this study is based on an analysis of 70 years of recorded mean wind speed data obtained at the meteorological recording station located within Kingsford Smith Airport in Sydney, from 1939 to 2008.

The Australian Standard AS1668.2-2002 requires a minimum of 2 ACH for air quality due to occupant related contaminants. Also to address the requirements of SEPP65, a benchmark was set for airflow velocity through a window of the main living space based on the performance of the least-performing corner or double ended unit, which in this development achieved a directionally weighted average velocity of 0.4m/s.

The results of the study for the current scheme indicates that without the inclusion of the proposed ventilation shafts, 65% of the residential apartments would achieve a natural ventilation performance equivalent to or better than a SEPP65 deemed to comply dwelling. The single aspect dwellings have been able to achieve adequate natural ventilation due to the stepped façade design with the external aspect located on the perimeter of the building envelope, the location of openings with respect to the prevailing breezes and the internal layout.

2.0 Description & Location of the Development

The proposed development consists of residential building located at 134-140 Marsden Street, Parramatta. An aerial image of the existing site is provided in Figure 1. The proposed building contains four different blocks which, although connected, are readily identifiable by their difference in height and/or the indents which run down the building between them. A schematic drawing of the site layout at level 5, which clearly shows the extent of each block is provided in Figure 2. Descriptions of the various blocks are as follows:

- Block A is located on the north side of the proposed site, and has residential apartments on Levels 3 to 25.
- Block B is located immediately south of Block A, and has residential apartments on Levels 2 to 24.
- Block C is located immediately south of Block B, and has residential apartments on Levels 2 to 21.
- Block D is located immediately west of Block C, and has residential apartments on Levels 2 to 10.

Directly west of the proposed site is a 12 story building. To the northwest, across Macquarie Street, is the Jessie Street Centre. East of the proposed site, across Marsden Street, are a number of commercial buildings with heights up to six storeys above ground. To the south east of the site is St John's Cathedral and beyond that is Westfields Parramatta.

Figure 1: Aerial Image of the Development Site

Figure 2: Proposed Site Plan of the Development

3.0 Wind Climate of the Sydney Region

The wind climate data used in this study is based on an analysis of 70 years of recorded 10-minute mean wind speeds obtained at the meteorological recording station located at Kingsford Smith Airport in Sydney, from 1939 to 2008. A plot of the wind speed observation data is presented in Figure 3 below, referenced to a height of 10m above ground in open terrain and converted to hourly means. This data is also presented in Table 1, which also presents the corresponding daily average 60 minute mean wind speeds. The frequency of occurrence of the regional winds is also shown in Figure 3 for each wind direction. Note that the recurrence intervals examined in this study are for the daily average winds.

The data indicates that the maximum wind speeds for the region are governed by southerly, north-easterly and westerly winds. These wind directions also correspond to the directions of the most frequent winds for the region.

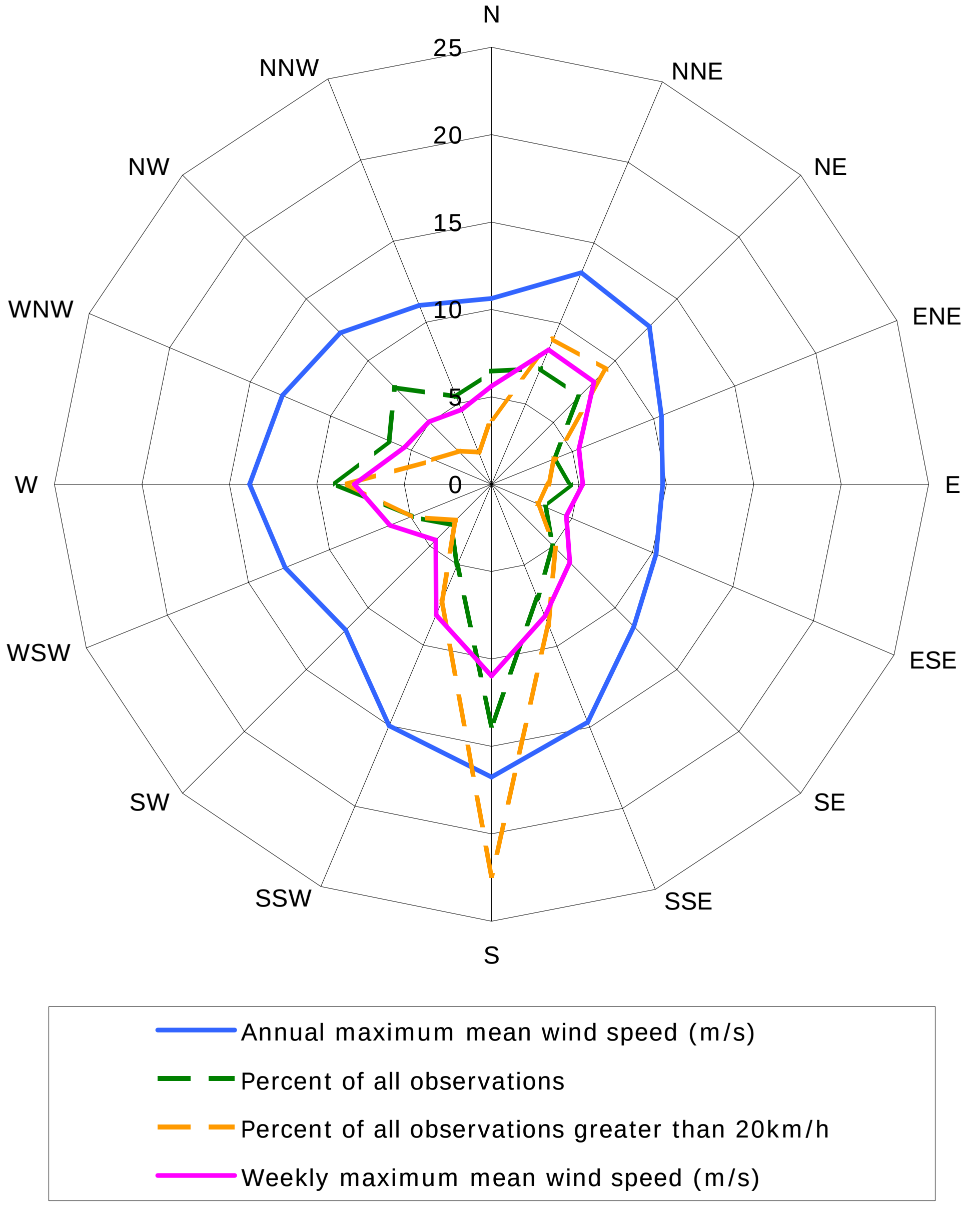

Figure 3: Annual and Weekly Maximum Hourly Mean Wind Speeds, and Frequencies of Occurrence, for the Sydney Region (referenced to open terrain at 10m)

Table 1: Regional Directional Wind Speeds for the Sydney Region (daily average 60 minute mean wind speeds and percentage of observations of wind direction, referenced to 10m height in open terrain)

Wind Direction	Percentage of Observation of Wind Direction (%)	Daily Average Wind Speed V_{ref} (m/s)
N	5.5	4.1
NNE	6.1	5.7
NE	6.0	5.7
ENE	3.3	4.8
E	3.9	4.3
ESE	2.9	4.6
SE	4.3	5.0
SSE	6.0	5.7
S	11.8	6.8
SSW	4.3	6.4
SW	2.8	4.8
WSW	4.2	5.0
W	7.6	4.9
WNW	5.4	4.2
NW	6.7	3.6
NNW	4.6	3.7

4.0 The Wind Tunnel Model

Wind speed measurements were carried out using a 1:300 scale model of the proposed development. The study model has been constructed based on architectural drawings prepared by the project architect Allen Jack + Cottier, received July 7, 2011. The study model incorporates all of the architectural features on the facades, except for those elements that have maximum sectional dimensions of less than approximately 1m, which is appropriate for this type of study.

The proximity model extends to a radius of approximately 375m from the centre of the subject site and includes all of the significant surrounding buildings and topographical effects.

The model of the proposed development was fitted with a total of 318 pressure taps (sensors) measuring the pressure coefficients at each of the opening locations to the residential units of the building. A total of 272 different internal flow path pairings have been considered for the residential units of the building for this study.

Photographs of the wind tunnel model that has been used for this project are presented in Figures 4a to 4c on the following pages. The layout of pressure taps used on the model are shown in Figures 5a to 5p in elevation and plan drawing formats.

Figure 4a: Photograph of the Model in the Wind Tunnel

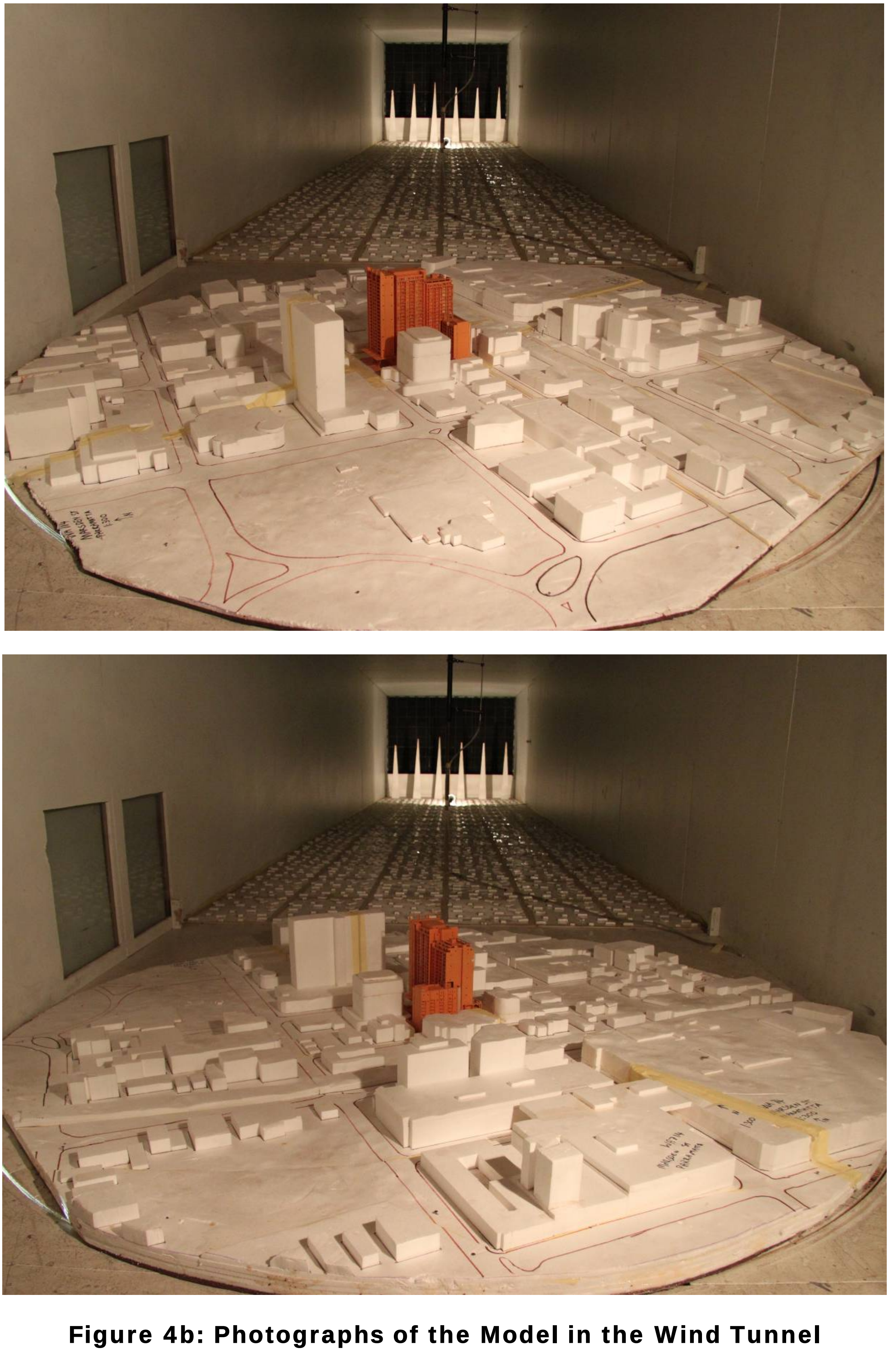

Figure 4b: Photographs of the Model in the Wind Tunnel

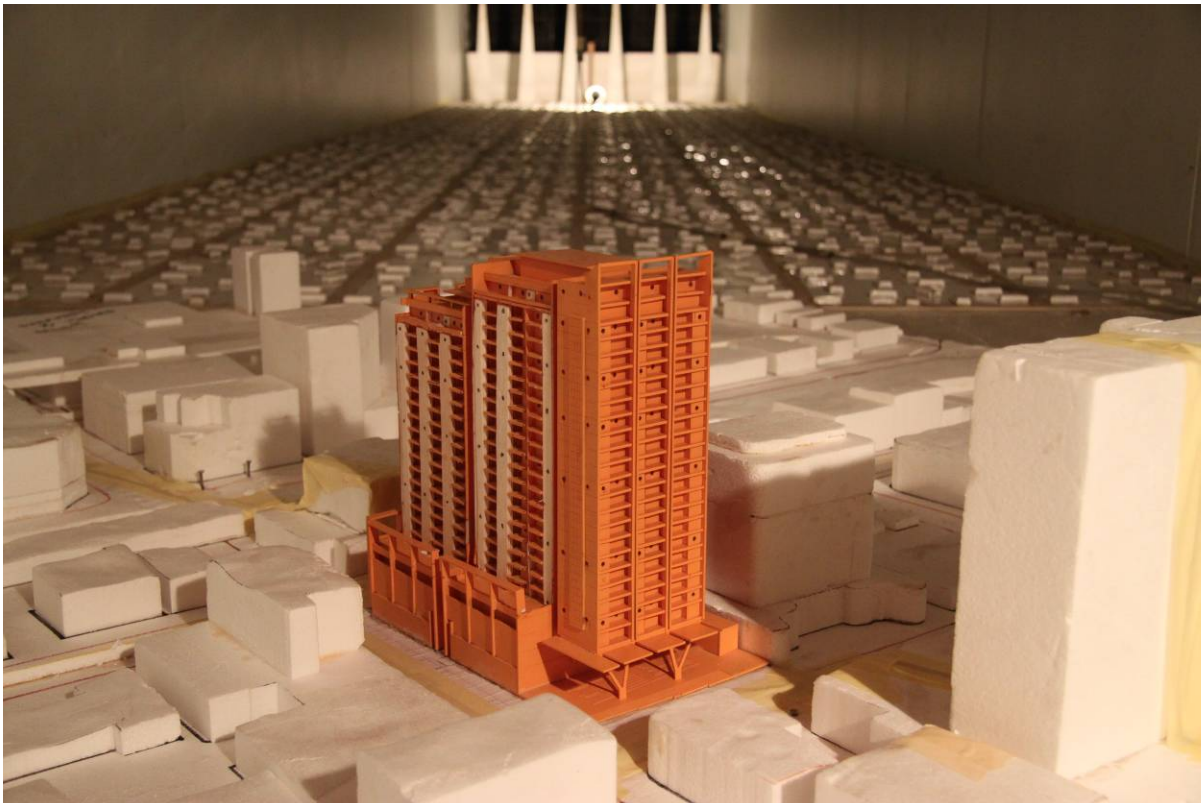

Figure 4c: Photographs of the Model in the Wind Tunnel

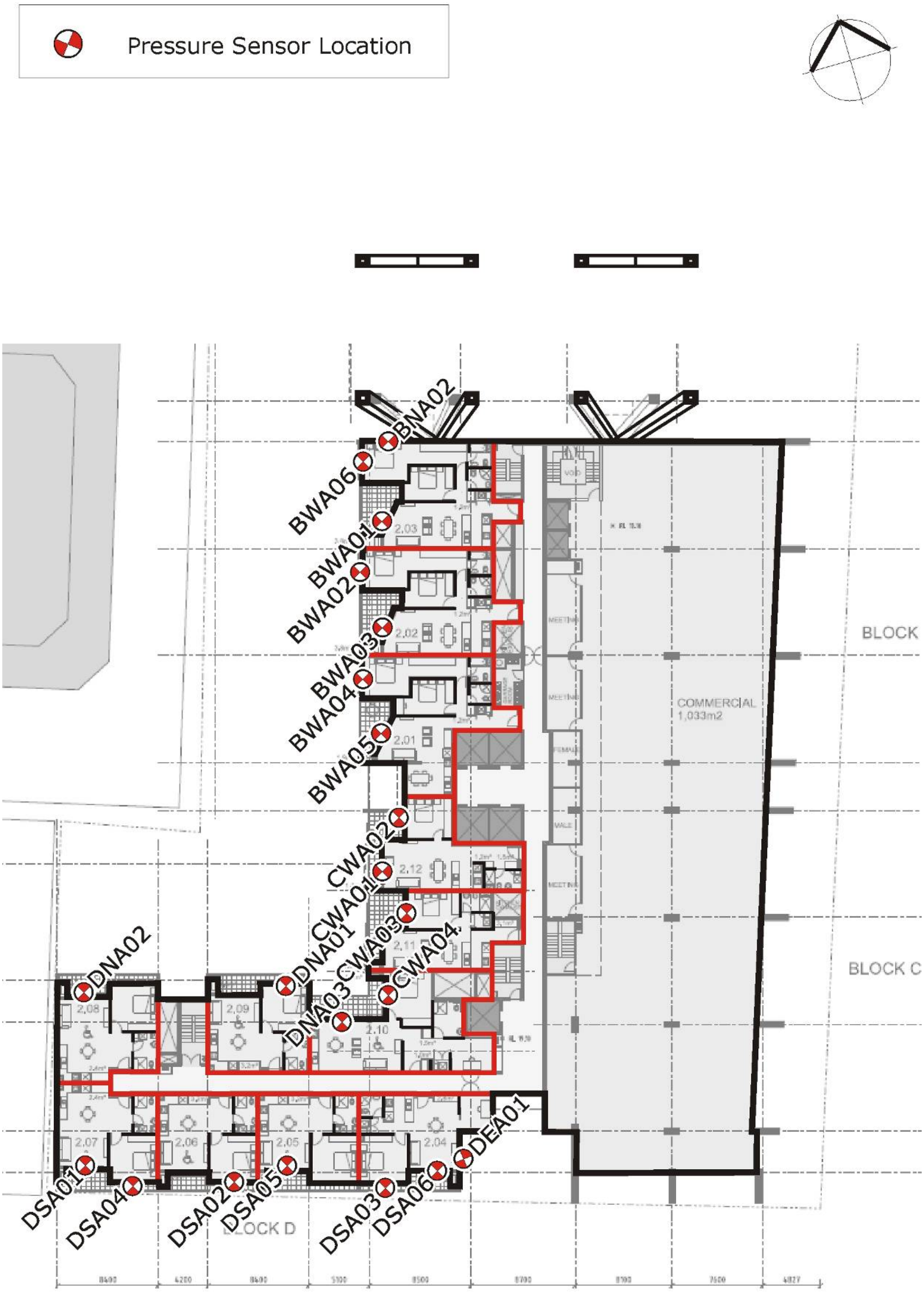

Figure 5a: Pressure Tap Layout - Level 2

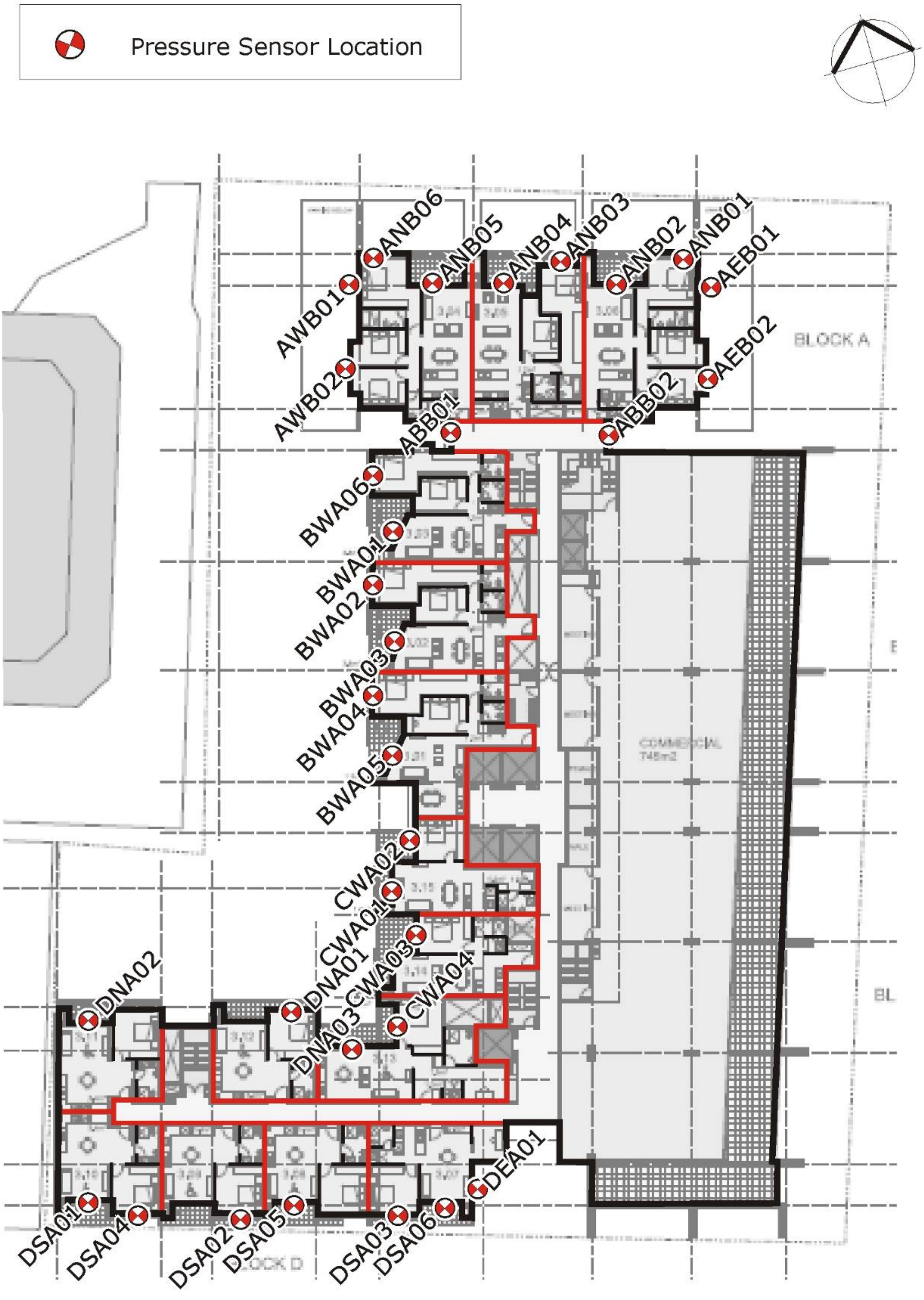

Figure 5b: Pressure Tap Layout – Level 3

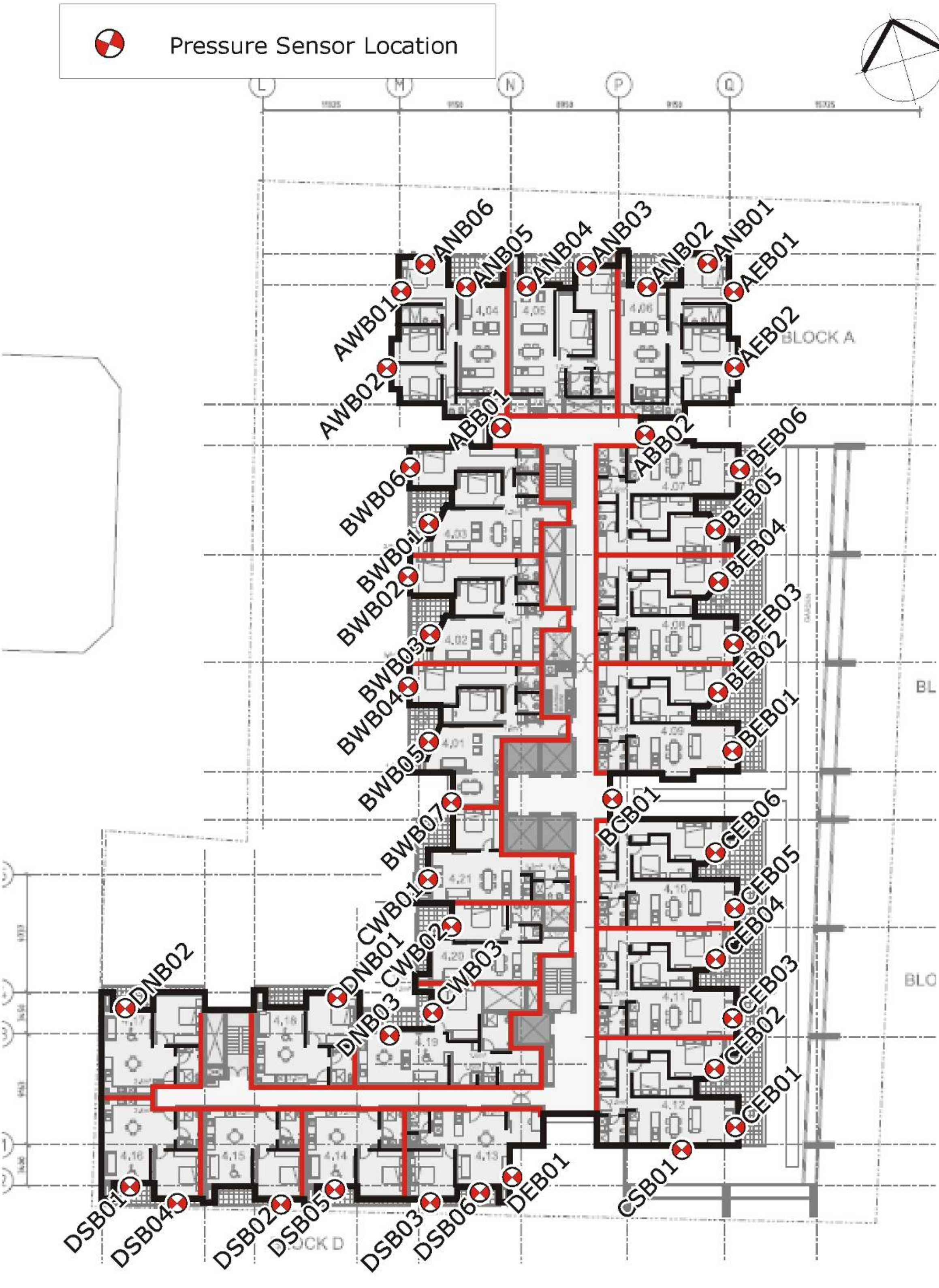

Figure 5c: Pressure Tap Layout - Level 4

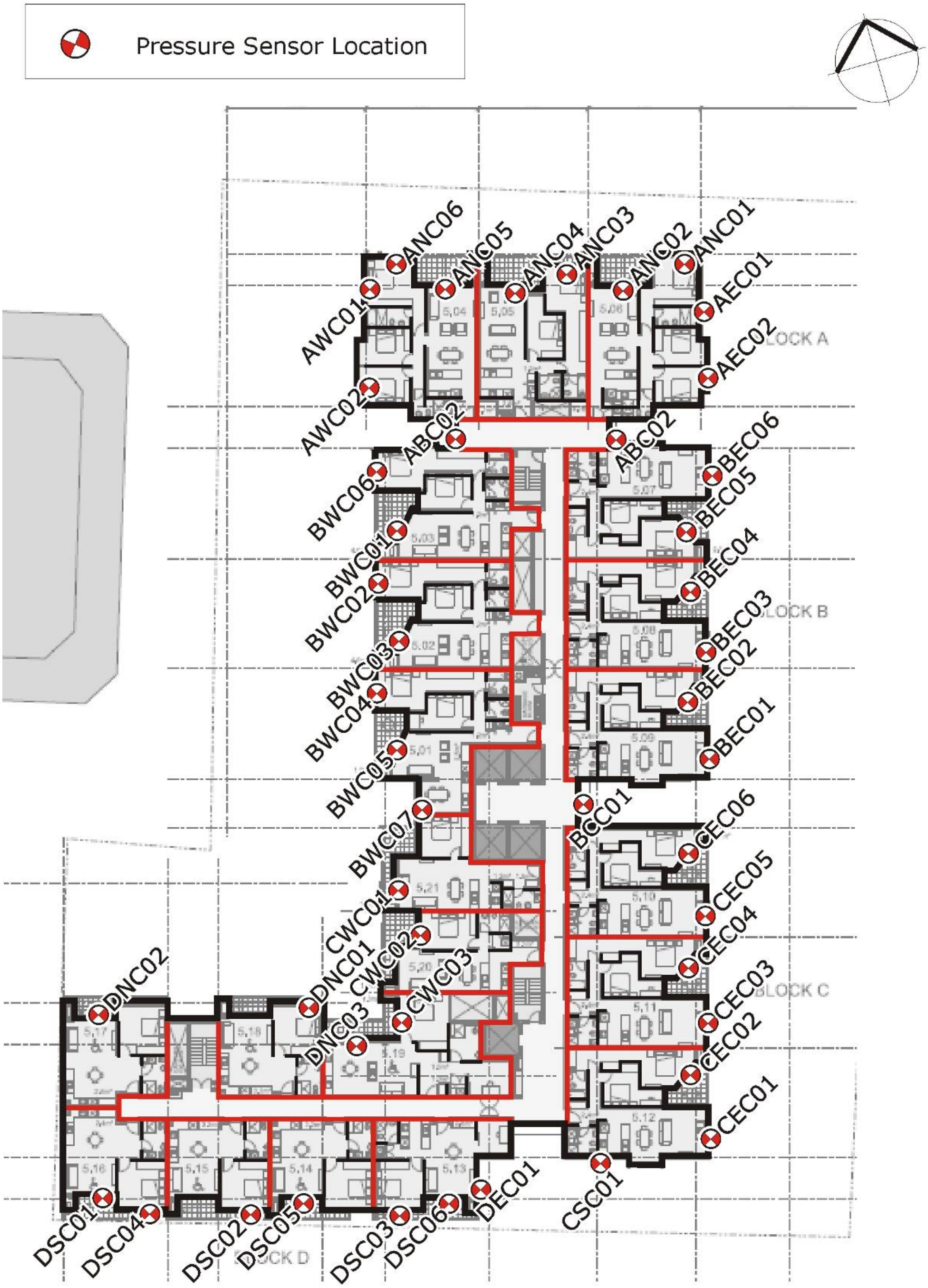

Figure 5d: Pressure Tap Layout - Level 8

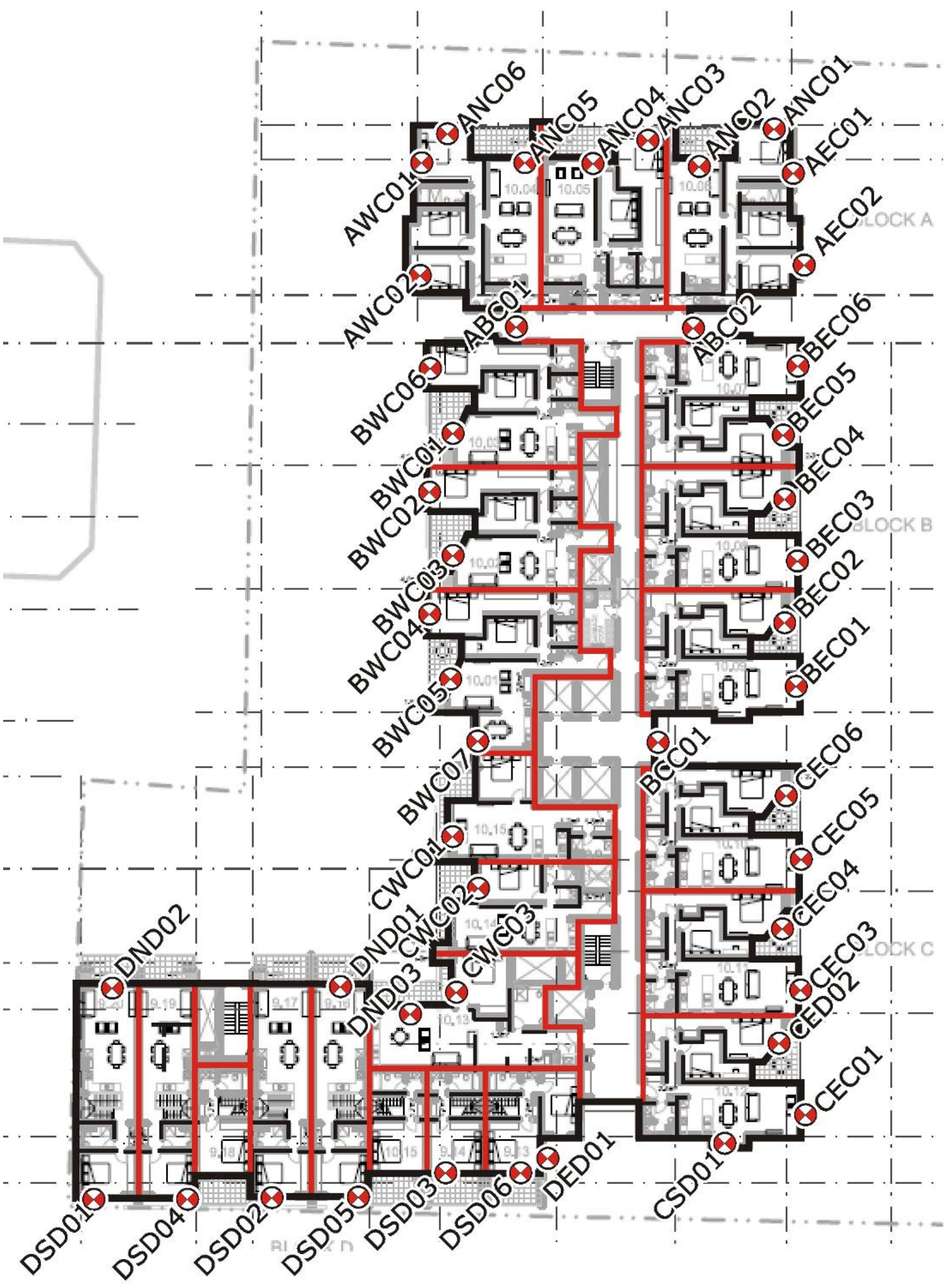

Figure 5e: Pressure Tap Layout - Level 10

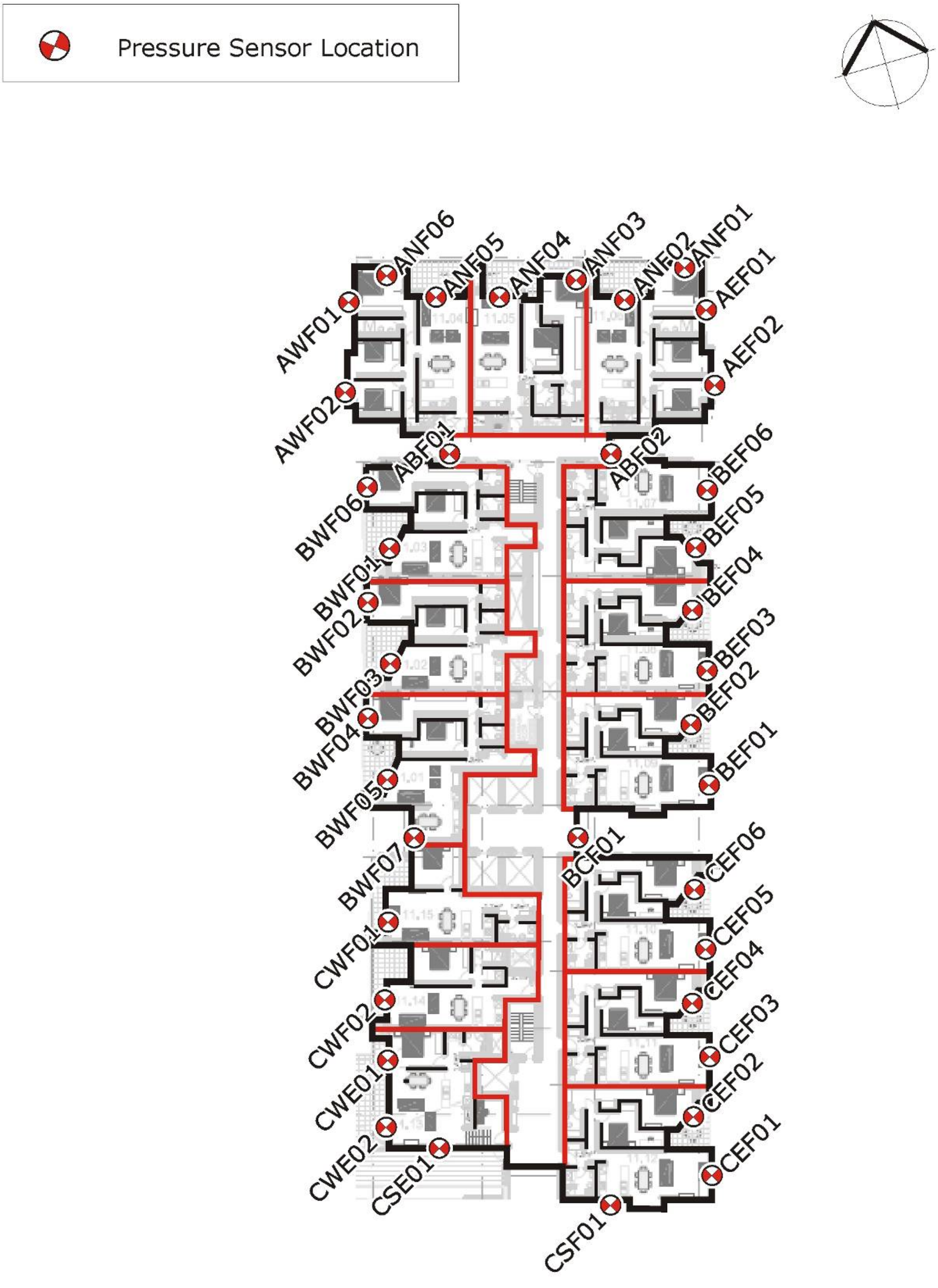

Figure 5f: Pressure Tap Layout - Level 11

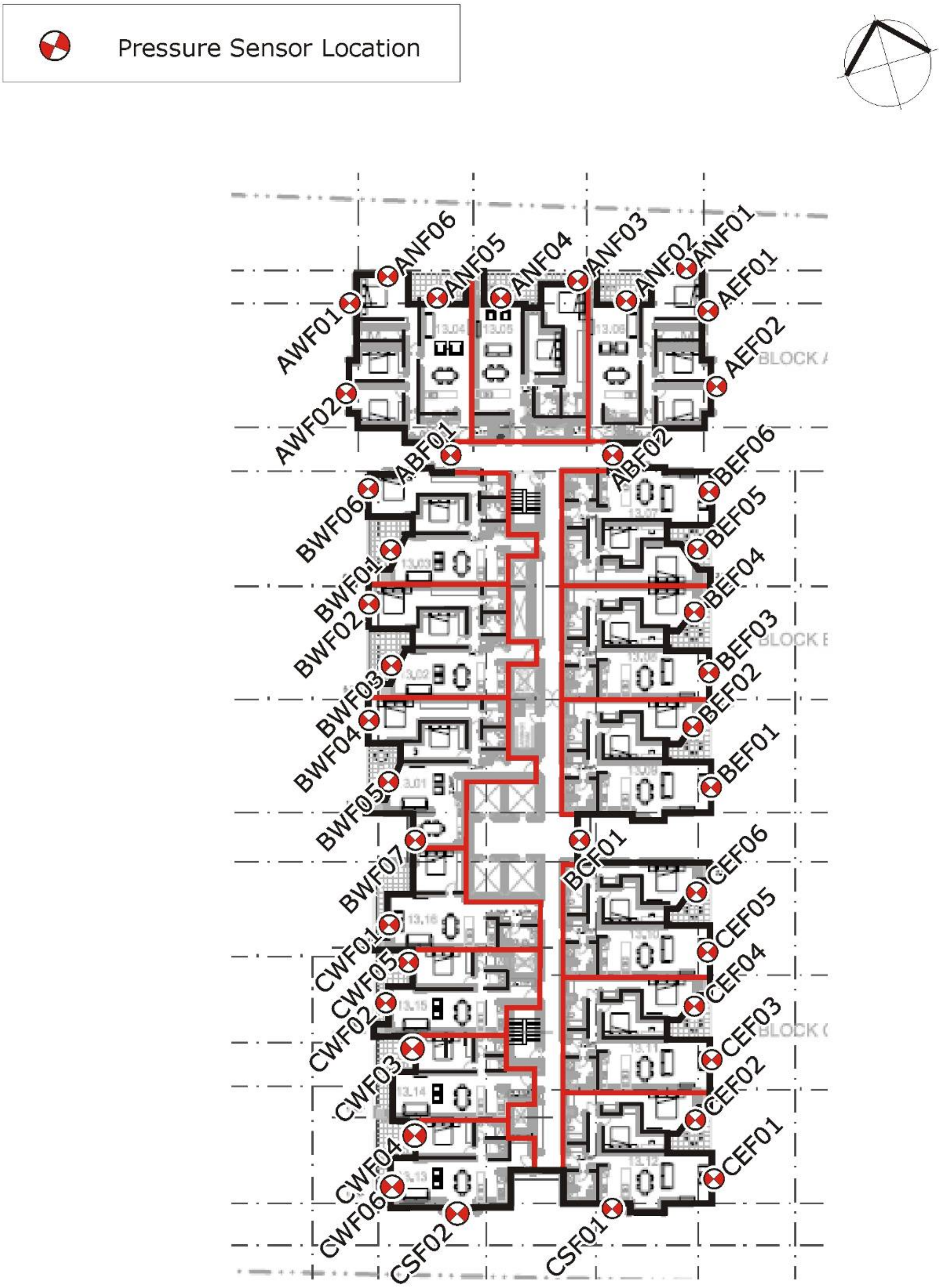

Figure 5g: Pressure Tap Layout - Level 13

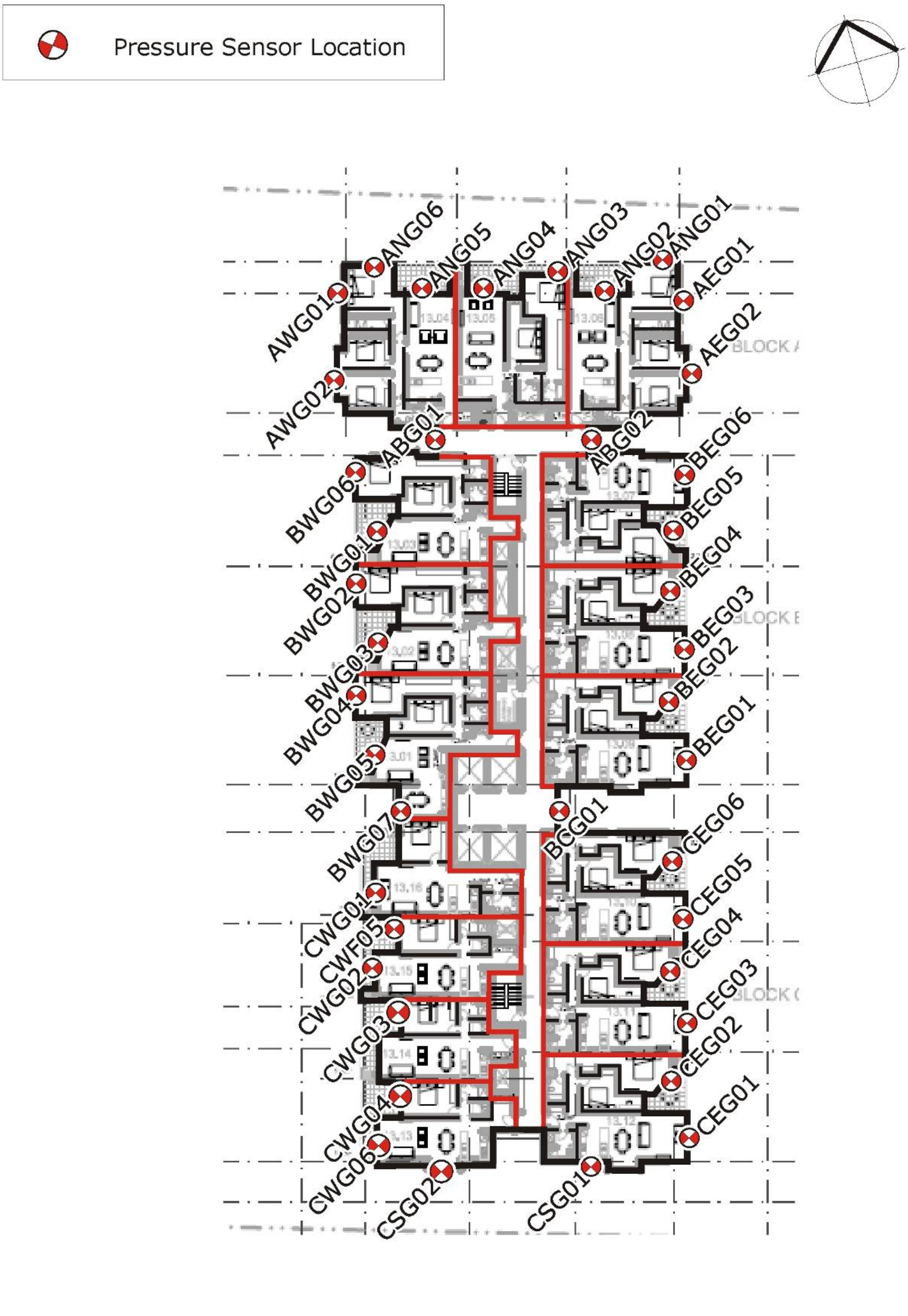

Figure 5h: Pressure Tap Layout - Level 17

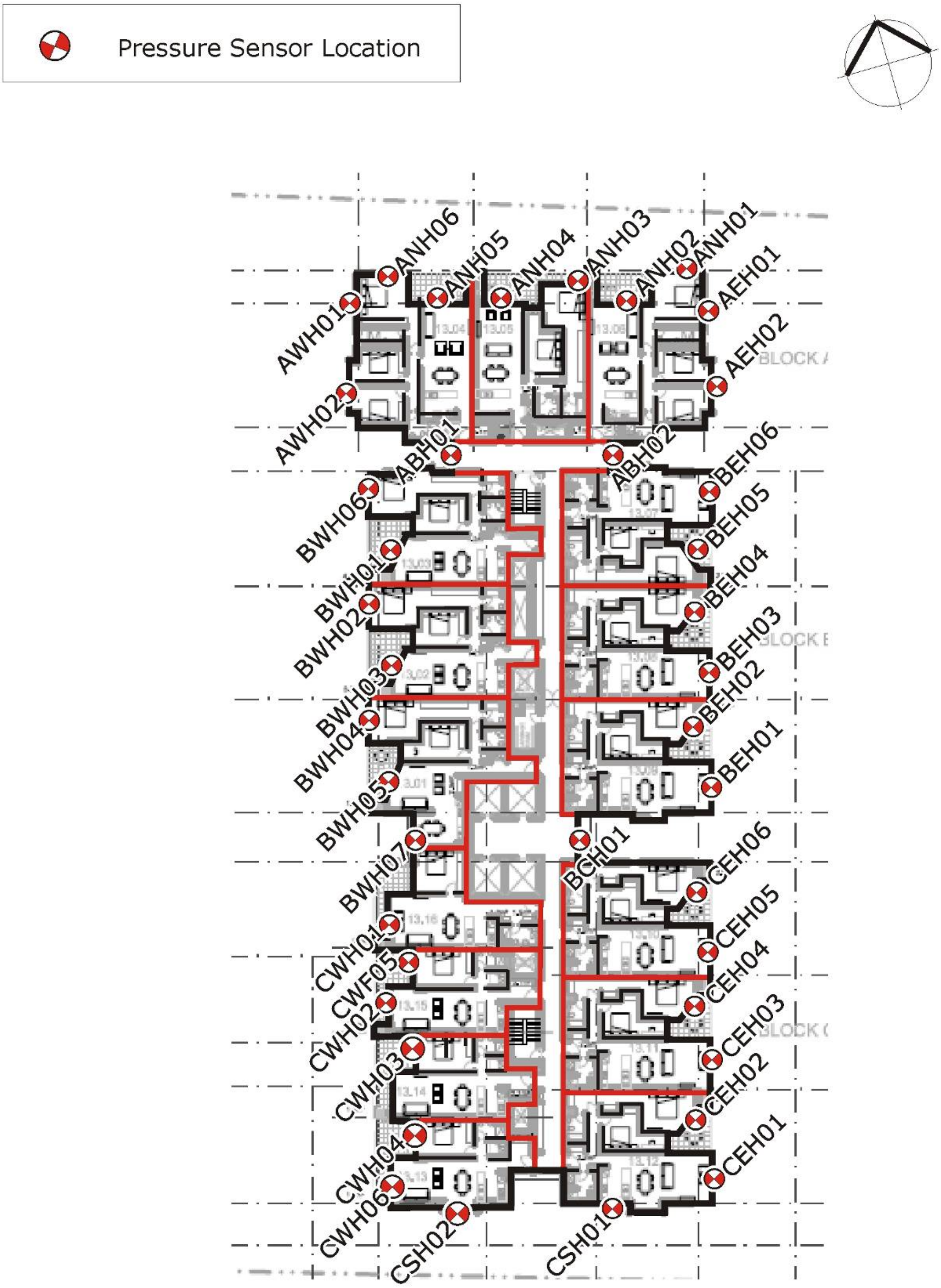

Figure 5i: Pressure Tap Layout - Level 20

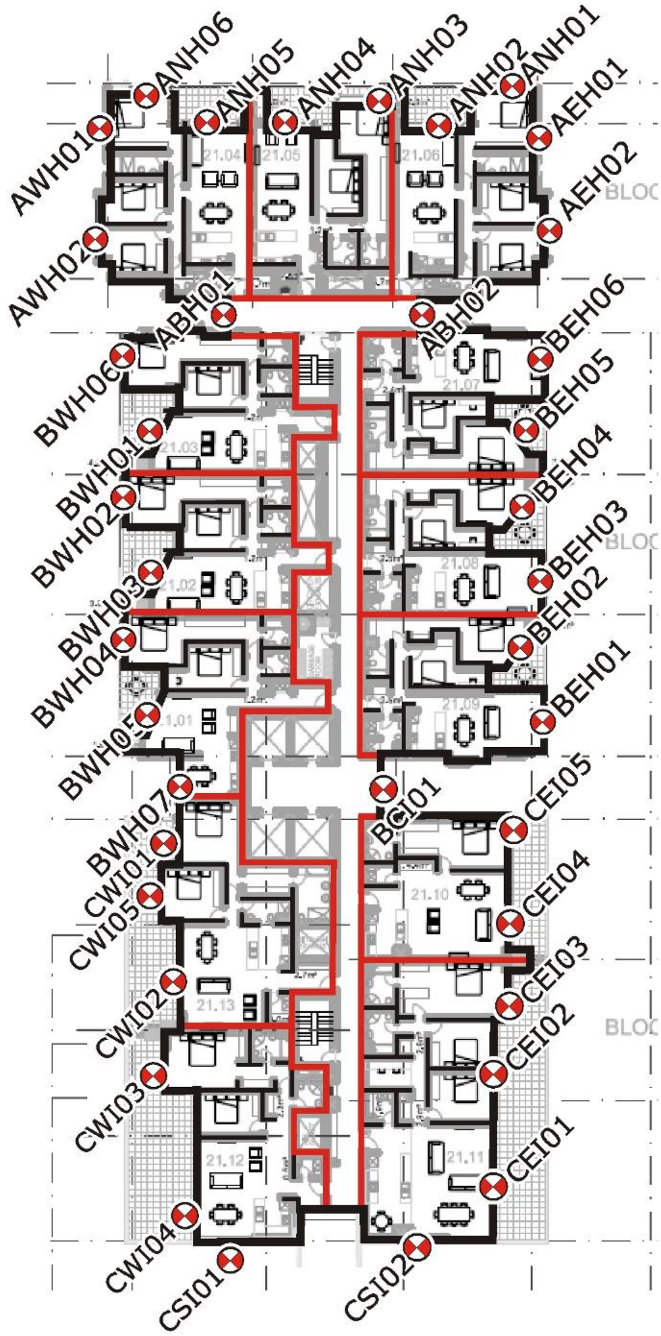

Figure 5j: Pressure Tap Layout - Level 21

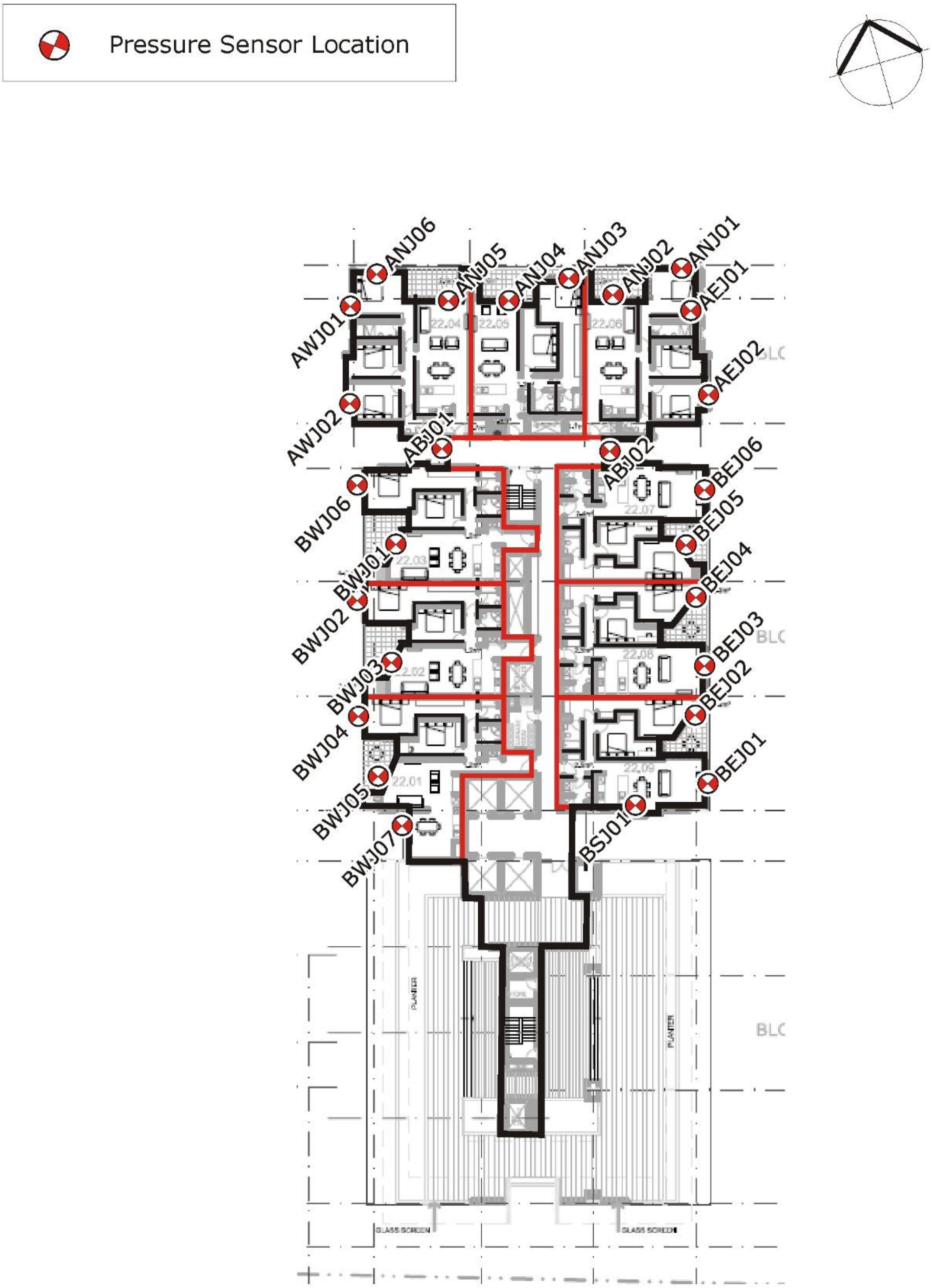

Figure 5k: Pressure Tap Layout - Level 22

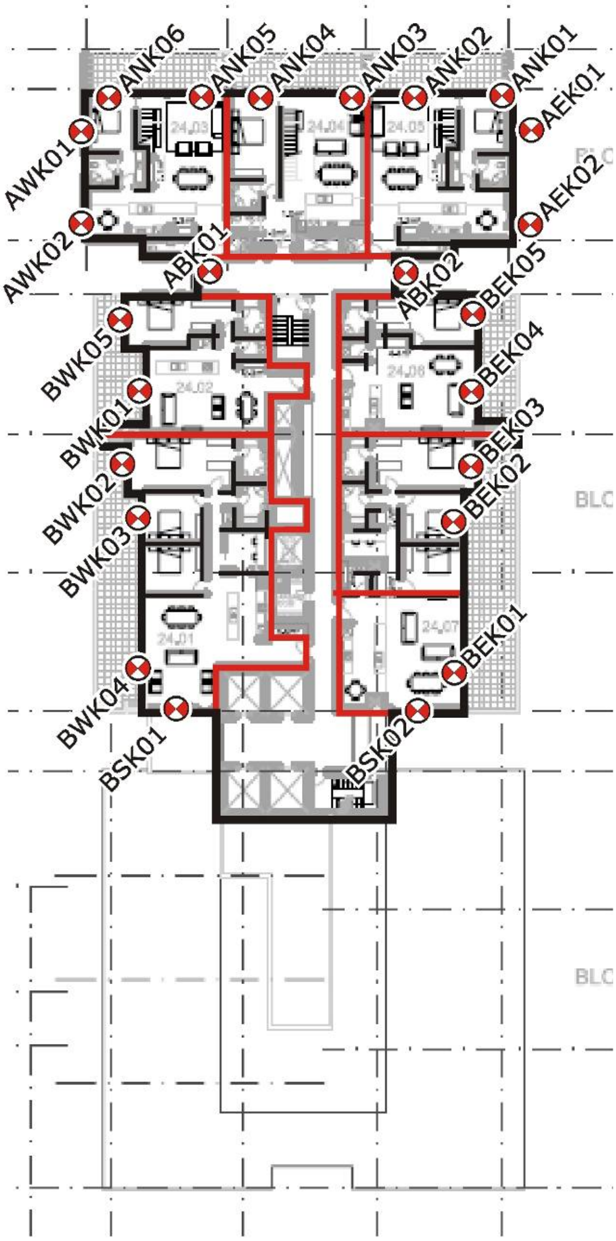

Figure 5l: Pressure Tap Layout - Level 24

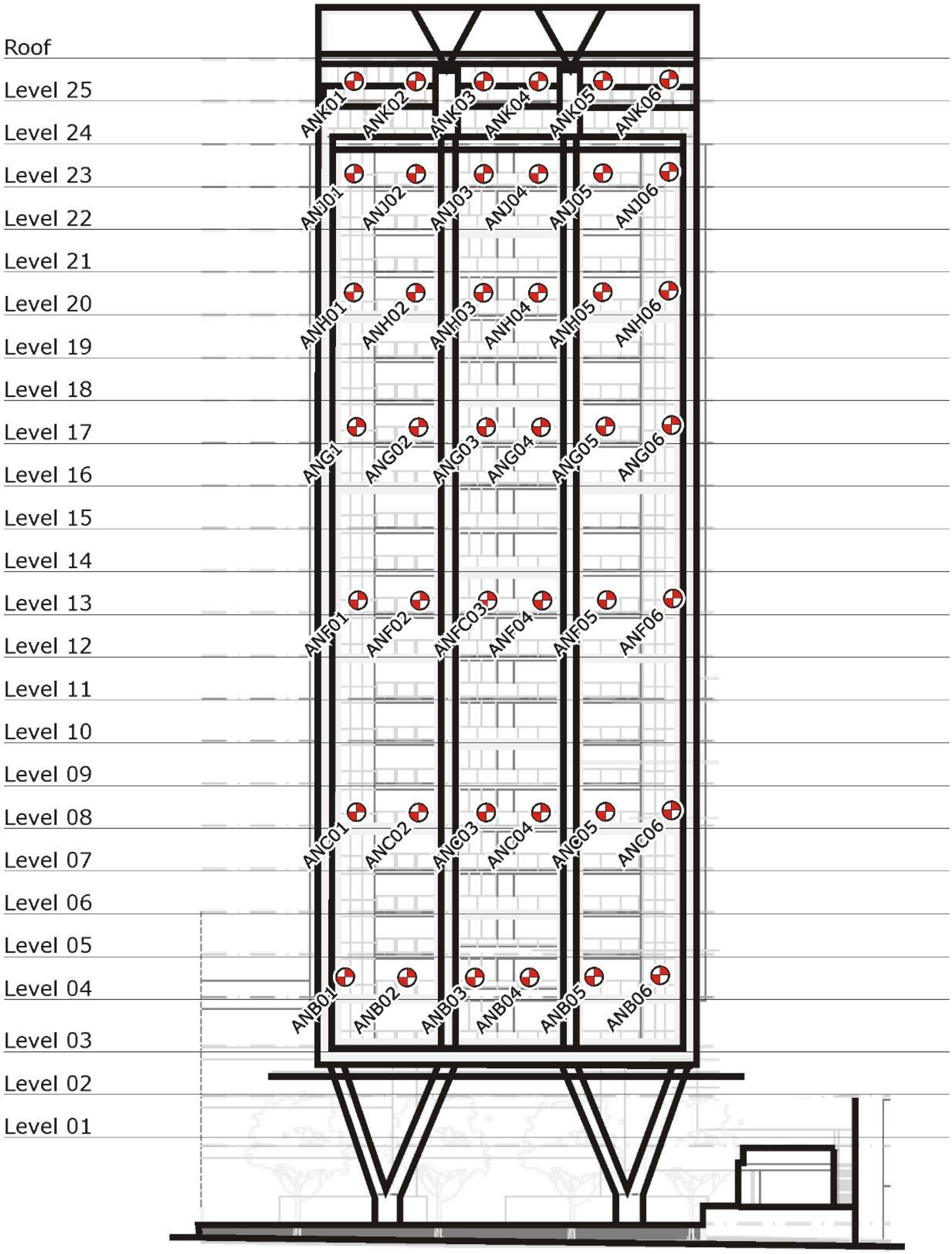

Figure 5m: Pressure Tap Layout – North Elevation

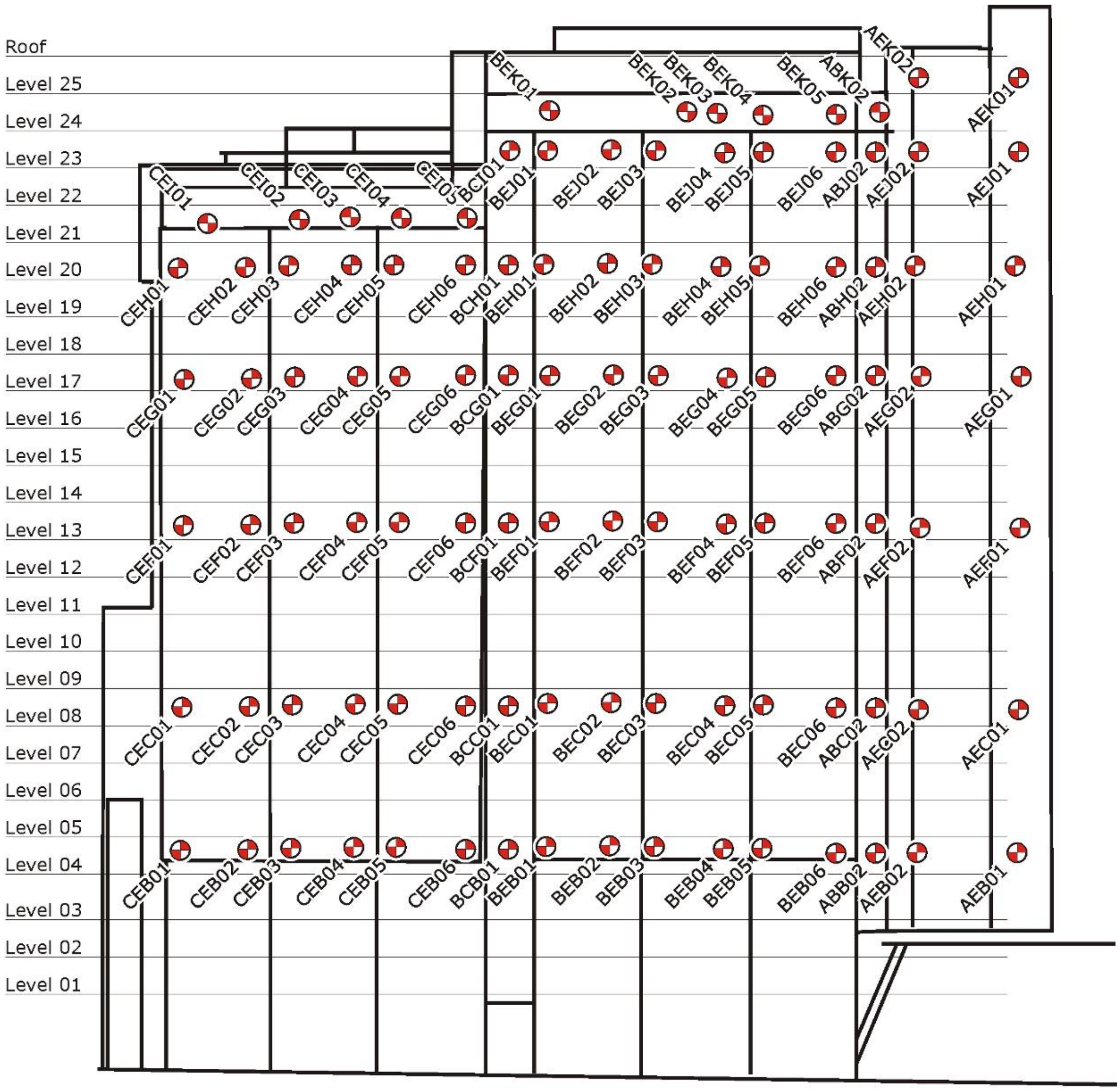

Figure 5n: Pressure Tap Layout – East Elevation

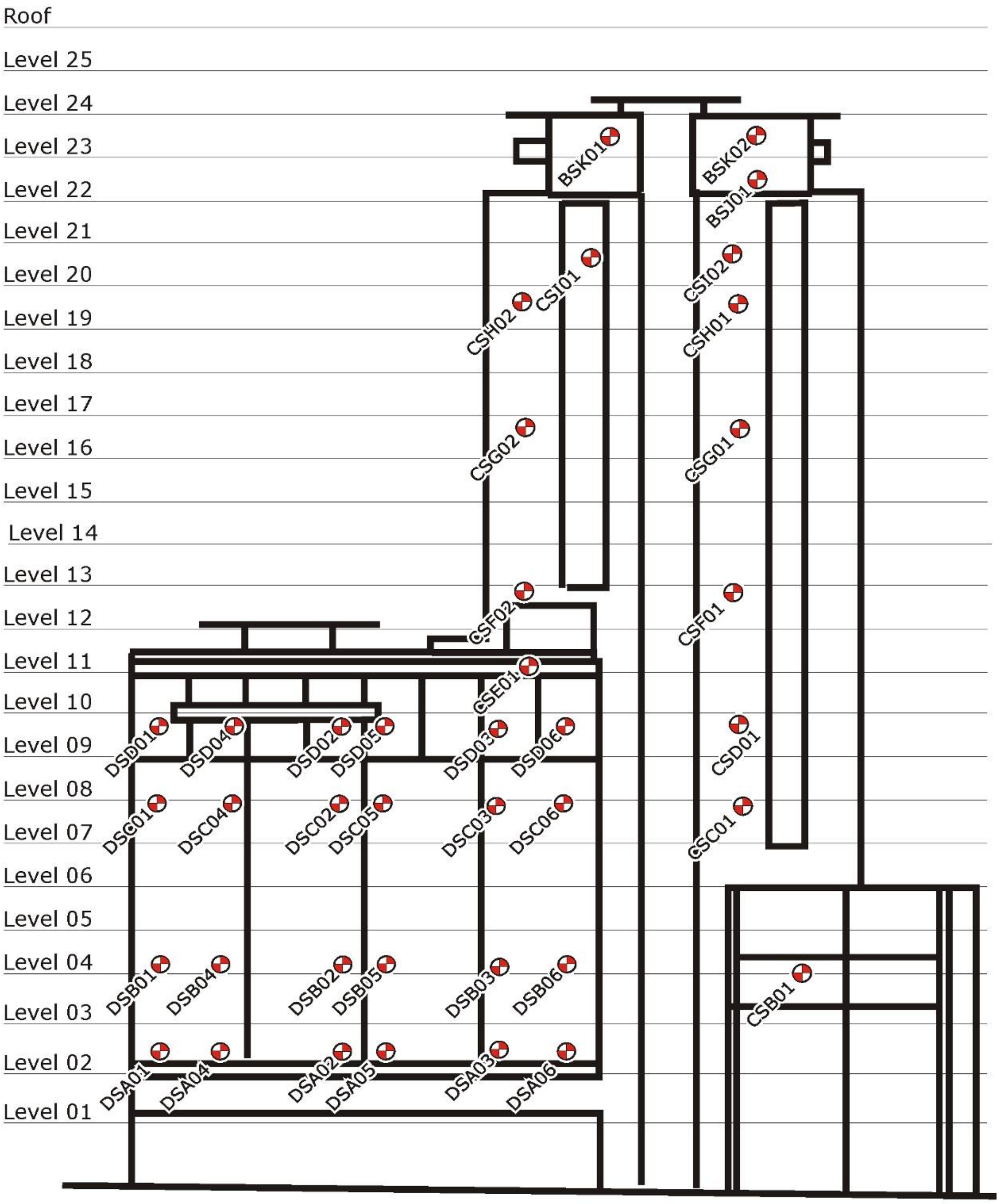

Figure 5o: Pressure Tap Layout – South Elevation

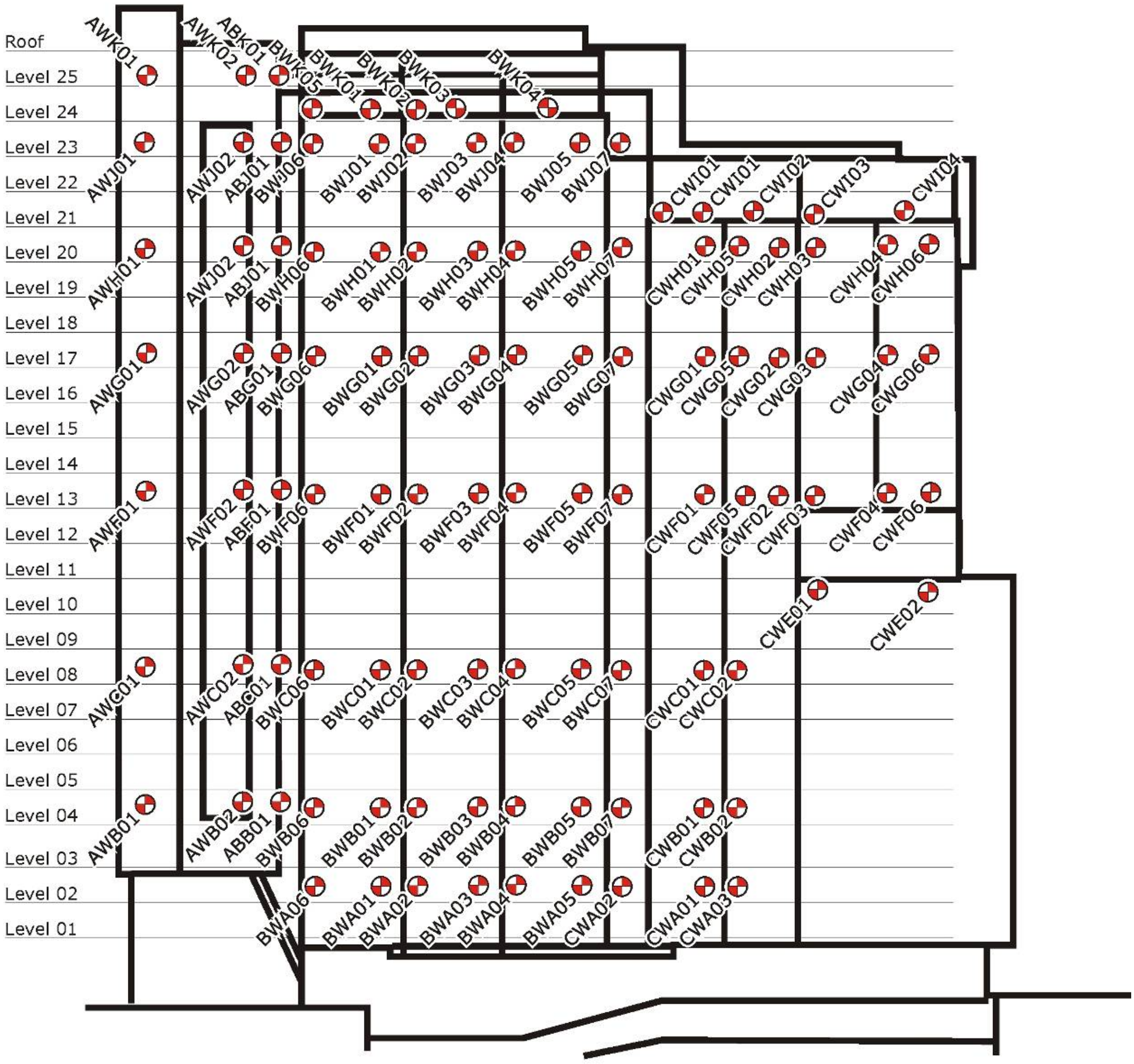

Figure 5p: Pressure Tap Layout – West Elevation

5.0 Boundary Layer Wind Flow Model

The approaching boundary layer wind flow modelled in the wind tunnel matched the model scale and the overall surrounding terrain characteristics beyond the 375m radius of the proximity model for each of the sixteen wind directions tested. For the fetch beyond the extent of the model the boundary layer wind profiles used in the wind tunnel are simulated based on the standard ISO/FDIS 4354:2008 model. The wind profile shape is calculated based on an analysis of the surrounding terrain for each wind direction tested. The roughness of the upwind terrain from the site determines the shape of the boundary layer wind profile for each wind direction tested.

The reference height used for the terrain analysis study was 84.7m above ground, and the fetch length used to determine the approaching wind profile was 3.4km. Note that the fetch length is calculated as being a distance of 40*h* from the edge of the proximity model, where *h* is the reference height used for the terrain analysis. The site location and the surrounding fetch area for the calculation of the approaching boundary layer wind flow is shown in Figure 6. This figure also shows whether the surrounding terrain within the fetch length is classified as open, suburban or urban.

The length of each terrain type, and the distance each terrain type is from the site, is analysed for each wind direction tested. When the wind travels from one terrain type to another, the mean velocity profile does not change instantly. A lag occurs, and is measured as a distance by the following equation:

$$x_i = z_{0,r}\left[\frac{z}{0.3z_{0,r}}\right]^{1.25} \tag{5.1}$$

where x_i is the lag length caused by the change in terrain type.

z is the height above ground.

$z_{0,r}$ is the larger of the two roughness lengths of the two terrain types (see Table 2).

The wind profile for each wind direction is calculated using the lag distance equation above, and the site terrain analysis data measured from the image shown in Figure 6.

For example, for wind coming from the west-north-west direction (292.5 degrees), it is assumed that the approaching wind profile at the outer edge of the fetch length (3.4km from the edge of the surrounds model) is the standard ISO/FDIS 4354:2008 suburban terrain profile, since this is coming from over the residential houses of Pendle Hill and Wentworthville. As the wind approaches the site it continues over the open terrain of Parramatta Park where the most appropriate standard wind profile is the ISO/FDIS 4354:2008 open terrain profile. The final wind profile for this wind direction, shown in Appendix D of this report, indicates that it is somewhere between the standard open and suburban terrain profiles.

The hourly mean, 10-minute mean, and 3-second gust terrain and height multipliers, and the corresponding roughness lengths, are summarised in Table 2 for the various standard ISO/FDIS 4354:2008 profiles, referenced to 84.7m above ground.

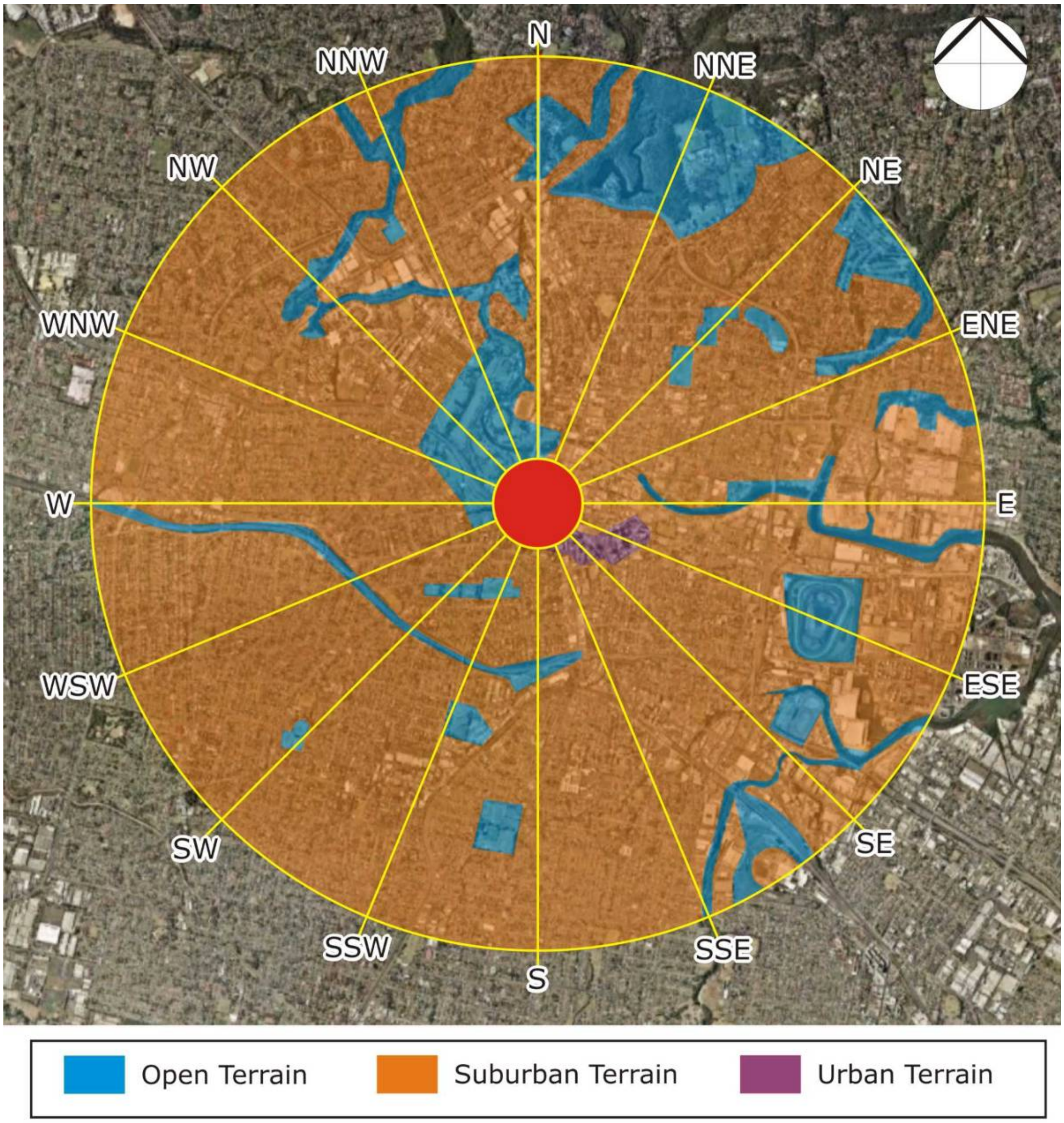

Figure 6: Surrounding Terrain Types (3.4km fetch length)

Table 2: Terrain & Height Multipliers and Turbulence Intensities, and the Corresponding Roughness Lengths (standard ISO/FDIS 4354:2008 profiles, at 84.7m above ground)

Terrain Description	Terrain & Height Multipliers (for 84.7m above ground)			Turbulence Intensity $I_{v,84.7m}$	Roughness Length (m) $z_{0,r}$
	$k_{tr,T=3600s}$	$k_{tr,T=600s}$	$k_{tr,T=3s}$		
Open	0.91	0.94	1.27	0.133	0.03
Suburban	0.76	0.81	1.20	0.190	0.30
Dense Urban	0.56	0.60	1.08	0.314	3.00

6.0 Reference Wind Speeds for the Study

The reference hourly mean wind speeds that are used for this study are calculated for each wind direction at the reference height of 84.7m above ground, at the upwind edge of the proximity model (375m upwind of the site). The hourly mean values of upstream wind speed at building height presented in Table 3 are derived from the daily average (50-percentile) 10-minute mean wind speed data obtained at the meteorological station at Sydney's Kingsford Smith Airport (see Table 1 of this report), which is referenced to a height of 10m in open terrain. The derived values in Table 3 incorporate the relevant hourly mean terrain and height multipliers that were calculated from the analysis of the surrounding terrain types (also shown in Table 3 below). Note that calm wind events were recorded for 14.7% of the observations.

Table 3: Reference Mean Terrain, Height Factors and Daily Average Wind Speeds at the Site, corrected to the Building Reference Height of 84.7m

Wind Direction	Hourly Mean Terrain & Height Multiplier $k_{tr,T=3600s}$	Percentage of Observations (%)	Daily Average Wind Speed at the site, at 84.7m above ground (m/s) $V_{daily@84.7m}$
N	0.80	5.52	5.0
NNE	0.84	6.14	7.3
NE	0.80	6.04	7.0
ENE	0.78	3.26	5.8
E	0.77	3.86	5.0
ESE	0.79	2.85	5.5
SE	0.77	4.25	5.9
SSE	0.78	5.97	6.8
S	0.76	11.77	7.9
SSW	0.77	4.30	7.5
SW	0.76	2.81	5.6
WSW	0.76	4.22	5.9
W	0.76	7.62	5.7
WNW	0.76	5.44	4.9
NW	0.77	6.68	4.2
NNW	0.77	4.60	4.3

7.0 Test Procedure

The testing was performed in Windtech's blockage tolerant boundary layer wind tunnel facility. The good agreement between Windtech's wind tunnel cladding pressure results and full-scale data from the Texas Tech Experimental Building provides some indication of the accuracy of Windtech's wind tunnel results (Rofail, 1995).

The maximum tunnel blockage generated by the model and the surrounding buildings was approximately 3 percent of the tunnel cross sectional area. However, due to the effective design of Windtech's blockage tolerant wind tunnel facility, no corrections for blockage generated by the model were required for this study.

The reference pressure was measured 3 metres upstream of the study building, at a height of 1.5 metres in the wind tunnel. The mean velocity at this reference position was measured to be 16.3m/s. A sample time of 16 seconds (model scale time) was used which corresponds to an average full-scale sample time ranging between 124 and 227 minutes which is suitable for this study.

Mean, standard deviation, maximum and minimum pressures were obtained from the wind tunnel measurements, which were made from 36 wind directions at 10 degree increments. Peak, maximum and minimum pressure coefficients were obtained using the standard upcrossing technique. In this method the pressure range of each signal is divided into very small bands. The data consists of the number of crossings of the various bands by the pressure signal in a positive slope (or negative slope for minimum pressures). This data is used to carry out a statistical analysis of the pressure signal, assuming a Poisson distribution for the number of crossings. The upcrossing analysis of the peak pressures is performed on-line. The peak maximum and minimum pressures are derived from Fisher Tippett Type I parameters (Holmes, 2001). This method produces peak pressures that are more repeatable than simply adopting the measured extreme value and is more efficient than the other statistical techniques as it requires only 30 minutes of sampling time (in full-scale) (Rofail & Kwok, 1991).

The pressure signal was first low-pass filtered at 500Hz and then digital filtering was applied over this range to provide an unbiased response from the pressure measurement system (Rofail et al., 2004). This corresponds to a full-scale frequency range of approximately 0 to 4 Hz in full-scale. The pressure signal was sampled at a rate of 1024 samples per second per channel.

The output from each pressure tap, is produced in the form of mean, standard deviation, absolute maximum, absolute minimum, up-crossing maximum, and down-crossing minimum pressure coefficients for each wind direction (with reference to the velocity pressure at the building reference height). The complete set of wind tunnel data, plotted for each pressure tap tested, is presented in Appendix D of this report.

The application of wind tunnel testing for the modelling of natural ventilation has been reported by Rofail and Aurelius (2004) and Peddie and Rofail (2010).

8.0 Designing for Natural Ventilation

Natural ventilation is a primary design concept to reduce or remove the requirement for mechanical ventilation and/or air-conditioning of a building. This inturn provides an environmental benefit by reducing greenhouse gas emissions due to constant demand for mechanical ventilation and air-conditioning by the occupants. It has also been found that a natural ventilated building will generally reduce the reliance of artificial lighting due to window opening locations to provide ventilation, also providing additional lighting aspects. It is not only environmentally that natural ventilation is beneficial, one other aspects is the financial benefit, both in construction and running costs of the development. Although a naturally ventilated designed building will require more window openings, the benefit of not having to install mechanical ventilation units greatly outweighs this cost. Running costs are also reduced with no ongoing mechanical ventilators and benefits from reduced reliance on artificial lighting. (Peddie and Rofail, 2010)

Furthermore, it has been found that a naturally ventilated building reduces what is commonly known as Sick Building Syndrome (SBS). (Chenvidyakarn, 2010 and Awbi, 2010). Occupants of mechanical or air-conditioned buildings are known to be susceptible to symptoms including itchy eyes, coughs, sneezes and drowsiness. This commonly leads to lower productivity or more people being off sick then when compared to naturally ventilated buildings.

8.1 Natural Ventilation Guidelines

The implementation of natural ventilation into the design of a building is something that should be incorporated from the early stages of the design process to ensure an effective design solution. There are several design guidelines, detailed below, which should be considered in the initial design process when designing for natural ventilation. Some of these may conflict with other climate responsive strategies (such as orientation and shading devices to minimise solar gain) or other design considerations. It is important to understand the general nature of natural ventilation and these guidelines provide some insight to the concept of natural ventilation.

1. In hot, humid climates, maximize air velocities in the occupied zones for bodily cooling. In hot, arid climates, night time ventilation for structural cooling, when the temperature is low is more advantageous.
2. Take advantage of topography, landscaping, and surrounding buildings to redirect airflow and give maximum exposure to breezes. Use vegetation to funnel breezes and avoid wind dams, which reduce the driving pressure differential around the building. Site objects should not obstruct inlet openings.
3. Shape the building to expose maximum surface area to breezes.
4. Use architectural elements such as wingwalls, parapets, and overhangs to promote airflow into the building interior.
5. The long facade of the building and the majority of the door and window openings should be oriented with respect to the prevailing summer breezes. If there is no prevailing direction, openings should be sufficient to provide ventilation regardless of wind direction.

6. Windows should be located in opposing pressure zones. Two openings on opposite sides of a space will increase the area ventilated. Openings on adjacent sides force air to change direction, providing ventilation to a greater area depending on window opening locations. The benefits of the window arrangement depend also on the internal layout of the room.

7. If a room has only one external wall, better airflow is achieved with two widely spaced windows to maximise pressure differentials.

8. If the openings are at the same level and near the ceiling, much of the flow may bypass the occupied level and be ineffective in diluting occupant level contaminants.

9. The stack effect requires sufficient vertical distance between openings be advantageous; the greater the vertical distance, the greater the ventilation potential.

10. Openings in the vicinity of the Neutral Pressure Level (NPL) are least effective for thermally induced ventilation. If the building has only one large opening, the NPL tends to move to that level, reducing the pressure potential across the opening.

11. Greatest flow per unit area of total opening is obtained by inlet and outlet openings of nearly equal areas. An inlet window smaller than the outlet creates higher inlet velocities. An outlet smaller than the inlet creates lower but more uniform air speed through the room.

12. Openings with areas much larger than calculated are sometimes desirable when anticipating increased occupancy or very hot weather.

13. Horizontal windows are generally better than square or vertical windows. This is because they enable airflow over a wider range of wind directions and are most beneficial in locations of shifting prevailing winds.

14. Window openings should be accessible to and operable by occupants to enable control of their environment conditions and comfort levels.

15. Inlet openings should not be obstructed by indoor partitions. Partitions can be placed to split and redirect airflow, but should not restrict flow between the building's inlets and outlets.

16. Vertical airshafts or open staircases can be used to increase and take advantage of stack effects. However, enclosed stair-cases intended for evacuation during a fire should not be used for ventilation.

17. Internal openings should make use of common walls either side of the opening to minimise restriction of the airflow through the opening.

8.2 Types of Natural Ventilation Openings

Natural ventilation openings include: (1) windows, doors; (2) roof ventilators and skylights; (3) stacks; and (4) specially designed inlet or outlet openings.

Windows transmit light and provide ventilation when open and can be operated by sliding vertically or horizontally; by tilting on horizontal pivots at or near the centre; or by swinging on pivots at the top, bottom, or side. The type of pivoting used is important for weather protection and airflow rate. For optimal weather protection a top pivoting window would most suitable, however a horizontal or vertically sliding window will provide the most beneficial airflow rate due to minimal resistance flow path through the opening.

8.2.1 External Openings

The natural ventilation of a unit is dependant on several factors, some of which are the location, size and type of external opening to the unit. As describe above, there are numerous types of external openings including windows, doors, louvres and vents. The efficiency of these openings to allow airflow into and out of the apartment is dependant on the type of opening and the effective opening area, and also the opening area in relation to the associated wall area.

This efficiency of the opening to allow airflow is know as the discharge coefficient C_d and for a standard window opening is approximately 0.65. Aynsley(1977) has detailed the discharge coefficient for a range of outlet area to wall area ratios.

8.2.2 Internal Openings

The internal layout of a unit is critical on the natural ventilation performance of the internal flow path. When considering the internal layout of a unit, two key factors need to be taken into account, including:

- Flow path through a unit;
- Internal openings between external openings of the unit.

The flow path through an apartment between two external openings will affect any potential energy loses of the airflow as it travels between two pressure potential areas (external openings). The amount of energy loss which will occur is dependant on the amount of contractions or funnelling of the airflow through the unit. This includes passing through doors and corridors, as well as bends in the internal flow path. Aynsley(1977) provides details for a typical range of discharge coefficients for different internal opening configurations depending on the location and size of the opening.

8.2.3 Roof Ventilators and Skylights

Roof ventilators provide a weatherproof opening to an internal space and generally operate as an air outlet. Capacity is determined by the ventilator's location on the roof; resistance the ventilator and its ductwork offer to airflow; its ability to use kinetic wind energy to induce flow by centrifugal or ejector action; and the height of the draft.

Natural draft or gravity roof ventilators can be stationary, pivoting, oscillating, or rotating. Selection criteria include ruggedness, corrosion resistance, storm proofing features, dampers and operating mechanisms, noise, cost, and maintenance. Natural ventilators can be supplemented with power-driven supply fans; the motors need only be energized when the natural exhaust capacity is too low. Gravity ventilators can have manual dampers or dampers controlled by thermostat or wind velocity.

A roof ventilator should be positioned so that it unrestricted to the prevailing winds. Turbulence created by surrounding obstructions, including higher adjacent buildings, impairs a ventilator's ejector action. The ventilator inlet should be conical or bell mouthed to give a high flow coefficient. The opening area at the inlet should be increased if screens, grilles, or other structural members cause flow resistance. Building air inlets at lower levels should be larger than the combined throat areas of all roof ventilators.

8.2.4 Stacks

Stacks or vertical flues should be located where wind can act on them from any direction. Without wind, the roof stacks are still able to remove internal airstack effect alone remove air from the room with the inlets. The resistance to airflow should be minimised to improve the effective ventilation due to stack effect.

A combination of above types of openings can be used to optimise the natural ventilation potential.

9.0 Method of Analysis

The results are first reduced into the form of pressure coefficients with respect to a reference mean velocity pressure at the building reference height. These external pressure coefficients can be defined by the following equations.

$$C_{p_{mean}} = \frac{\bar{p} - p_0}{\frac{1}{2}\rho \bar{V}_{BH}^{\,2}} \quad (9.1) \qquad C_{p_\sigma} = \frac{p'}{\frac{1}{2}\rho \bar{V}_{BH}^{\,2}} \quad (9.2)$$

$$C_{p_{\max}} = \frac{p_{\max} - p_0}{\frac{1}{2}\rho \bar{V}_{BH}^{\,2}} \quad (9.3) \qquad C_{p_{\min}} = \frac{p_{\min} - p_0}{\frac{1}{2}\rho \bar{V}_{BH}^{\,2}} \quad (9.4)$$

Definitions of the terms above are described as follows:

$C_{p_{mean}}$	mean pressure coefficient	$\bar{p}$	mean pressure (Pa)
C_{p_σ}	standard deviation pressure coefficient	p'	standard deviation pressure (Pa)
$C_{p_{\max}}$	maximum pressure coefficient	$p_{\max}$	maximum pressure (Pa)
$C_{p_{\min}}$	minimum pressure coefficient	$p_{\min}$	minimum pressure (Pa)
ρ	air density (kg/m^3)	p_0	reference static pressure (Pa)
$\bar{V}_{BH}$	mean velocity at the building reference height (m/s)		

Appendix A presents the directional results for the maximum and minimum mean and peak external pressure coefficients, for each pressure tap location. All coefficient data presented in this report is referenced to the mean velocity pressure at the building reference height.

As detailed in Section 4.0 of this report, the reference location used for the wind tunnel measurements is 1.5m height and 3 metres upstream from the model. This is to ensure that the pitot-static probe, the instrument used to measure the static and total pressure during testing, is located in a low turbulence region of the approaching boundary layer wind profile in the wind tunnel. This height also avoids any interference with the wind flow onto the model. Hence, the pressure coefficients measured in the wind tunnel require an adjustment factor to be applied. This is to correct for the difference in the velocity pressure between the reference location and the model height of the proposed development. Note that the pressure coefficients presented in this report have already had this adjustment factor applied, and no further corrections are necessary. The correction for the difference in the static pressure has been discussed above.

The reference pressure is related to the reference mean wind speed by the following equation;

Reference Pressure (kPa) $= \frac{1}{2}\rho V^2 = \left(0.6\times10^{-3}\right)V^2$

where the air density ρ is taken to be 1.2 kg/m^3,
which is typical for sea-level atmospheric conditions.

9.1 Natural Ventilation Driving Mechanisms

Natural ventilation is driven by pressure differences across the openings caused by ambient pressure and temperature differences between different openings within a unit. Alternatively, the differences can be between the internal pressure in a unit and the roof pressure in the case of a room having an auxiliary ventilation system using roof vents (stack effect). For a mid-wall unit the internal pressure is dominated by the pressure at the dominant opening to the unit from the balcony etc.

Natural ventilation is the intentional flow of outdoor air due to wind and thermal pressures through controllable openings and can be used to effectively control both temperature and contaminants, particularly in mild climates. Temperature control by natural ventilation is often the only means of providing cooling when mechanical air-conditioning is not available. The arrangement, location, and control of ventilation openings should combine the driving forces of wind and temperature to achieve desired ventilation rate and good distribution of fresh air through the building.

Our experience is that thermally driven components in natural ventilation are negligible when compared with the pressure driven components. Thermal driven ventilation is becomes more dominant with large, multi-storey internal voids with purpose designed solar/thermal walls.

9.1.1 Wind Driven Ventilation

The characteristics and locations of the external and internal openings determine the above wind driven pressure differences and the resultant flow of air. The wind pressures acting on different openings will determine the internal static pressure of the tunnel in order to maintain the continuity equation (mass flow rate of air into the tunnel is equal to the mass flow rate of air out of the tunnel).

The wind driven ventilation between three or more openings in series can be determined by the following:

$$Q = \left[\frac{\left(C_{p_1} - C_{p_{n+1}}\right) v_z^2}{\frac{1}{C_{d_1}^2 A_1^2} + \frac{1}{C_{d_2}^2 A_2^2} + \frac{1}{C_{d_3}^2 A_3^2} + \ldots + \frac{1}{C_{d_n}^2 A_n^2}} \right]^{\frac{1}{2}} \tag{9.5}$$

C_{p_1}	mean pressure coefficient at Opening 1	v_z	Reference wind speed at height z (m/s)
C_d	discharge coefficient of the opening	A	openable area of the opening (m^2)
Q	mass flow rate along the flow path through the unit (m^3/s)	v_1	average velocity at opening 1 (m/s)

The equivalent air-speed within the unit has then been determined from Equation 9.6 below. The air-speed which would be experienced by the occupant of the apartment has been determined based on a nominal internal area of 2.0m^2. A nominal size internal area of approximately an internal corridor open has been taken as this provides a more suitable internal air-speed. It is assumed that the external doors and windows will be opened completely to achieve natural ventilation, however the occupants would not necessarily want to stand ajacant to a window opening to experience this affect.

$$v_{\text{internal}} = \frac{Q}{A_{\text{internal}}} \tag{9.6}$$

The average airflow through the internal space is taken as the weighted average of the airflow for all wind directions weighted based on the daily average percentage of occurrence of observations for Sydney. Note that the percentage of occurrence for each wind direction also takes into account the percentage of calm events for the Sydney region.

9.1.2 Thermal Effects

Temperature differences between indoors and outdoors cause density differences, and therefore pressure differentials that drive natural ventilation. During the heating season, the warmer inside air rises and flows out of the building near its top. It is replaced by colder outdoor air that enters the building near its base. During the cooling season, the flow directions are reversed and generally lower, because the indoor outdoor temperature difference is smaller.

The height at which the interior and exterior pressures are equal is called the Neutral Pressure Level (NPL) (Tamura and Wilson 1966, 1967). Above this point (during heating season), the interior pressure is greater than the exterior; below this point, greater exterior pressure causes airflow into the building.

The pressure difference due to the stack effect at height h is;

$$\Delta P_s = (\rho_o - \rho_i) g (h - h_{NPL}) \tag{9.7}$$

$$= \rho_i g (h - h_{NPL}) \frac{(T_i - T_o)}{T_o} \tag{9.8}$$

$$= \frac{1}{2} \rho_i V^2 . C_d \tag{9.9}$$

ΔP_s	Pressure difference due to stack effect	T	Average absolute temperature ($^\circ C$)
ρ	Air density (kg/m^3)	C_d	Discharge Coefficient
g	Gravity constant (m^2/s)	V	Average airflow velocity through the opening (m/s)
h	Height of observation (m)	h_{NPL}	Height of neutral pressure level (m)
i	inside	o	outside

Available data on the NPL in various kinds of buildings is limited. The NPL in tall buildings varies from 0.3 to 0.7 of total building height (Tamura and Wilson 1966,67). A value of 0.5 of the height provides adequate accuracy in most applications.

10.0 Criteria for Acceptance

The requirements for natural ventilation is focused on two main facets of flow through a room, these include the air quality within an associated room and also the flow rate or velocity through a room. The requirement for air quality is associated with improving the 'health' of a building and reducing what is commonly known as Sick Building Syndrome (SBS). This is encouraged by the circulation and replacement of air within a building with fresh outdoor air. The second facet is associated with a cooling sensation of airflow over a persons body. The ability to generate a comfortable rate of airflow over the occupants of a room reduces the reliance of mechanical ventilation or air-conditioning to cool the occupants of a room.

The requirements of the two areas of natural ventilated are explained in the below section, while the effect of these areas on the BCA and SEPP65 is also explained.

10.1 Air Changes per Hour (ACH)

The requirement for air quality within a given room is detailed in the Australian Standard AS1668.2-2002 and the American Standard ANSI/ASHRAE 62.1-2004. Both of these standards consider the need for air quality due to the following two reasons:

- *Occupant Related Contaminants* – This relates to contaminants produced by the occupants of the specified space and is dependent on the type of room, metabolic rate of activity conducted in the room and the number of occupants expected at anytime in the room.
- *Material Related Contaminants* – This relates to the expected contaminants generated by the materials associated with specific rooms and the expected uses.

It should be noted that both of these standards provide general expected contaminant production and number of occupants for the specified room. Furthermore, it should also be noted that the requirements for air changes per hour is significantly higher for mechanically ventilated rooms due to the mechanical systems recycling the existing internal air, while natural ventilation makes use of 'fresh' outside air.

The required air changes per hour based on the two abovementioned standards is presented in Table 4.

Table 4: Comparison of the Requirements for Air Changes Per Hour on the Various Ventilation Codes

Outdoor Air Requirements	AS1668.2-2002	ANSI / ASHRAE 62.1-2004
Occupant Related Contaminants Required ACH	2.0	-
Material Related Contaminants Required ACH	0.5	-
Combined Required ACH for Contaminants	-	0.8

10.2 Air-Speed

The current thought with regards to the assessment of the adequacy of natural ventilation is that it should be based on air-speed within the unit rather than simply the amount of air-changes per hour (S. Selkowitz, 2004). This is because the human body reacts more to the air-flow rather than just the quality of the air. It is considered that an acceptable benchmark for a minimum average daily air speed in a room is of the order of 0.8-1m/s. Airflow in excess of 1m/s starts to have an opposite effect on the occupant of the unit area. This is due to high airflow speeds causing papers etc to move due to the airflow. The relationship between air-speed and cooling sensation is well documented (for example Aynseley and Su, 2005). Figure 7a shows how the movement of air over one's body can induce a cooling sensation. Note that this relies on the person feeling hot such that there is humidity present on the surface of the body.

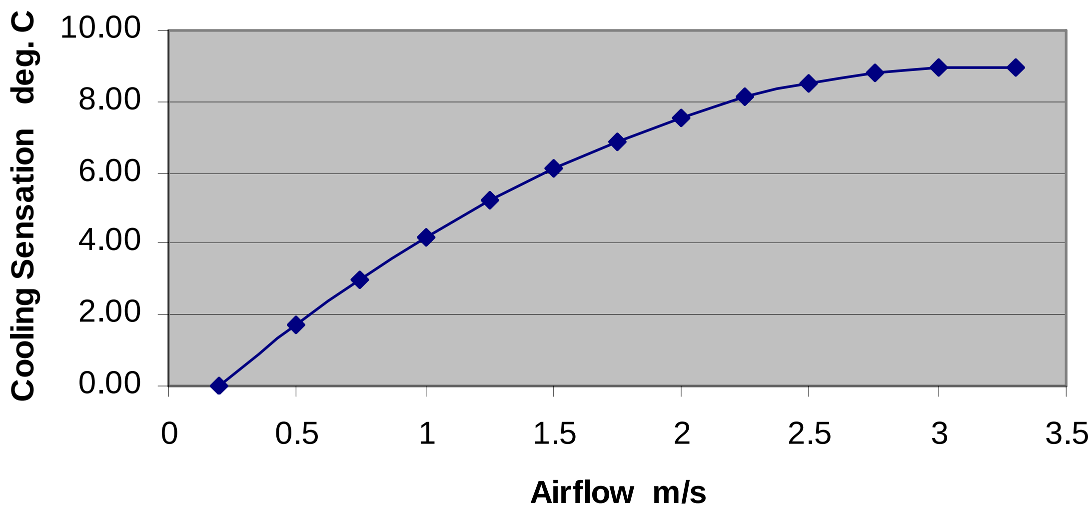

Figure 7a. Cooling Sensation of Air Flow (Aynsley and Su, 2005)

10.3 Building Code of Australia (BCA)

There is no definitive criterion in the BCA regarding the minimum flow required. Hence this exercise sets out to benchmark the performance of the corner-units and the double-ended units within this development as a minimum standard. A double-ended unit is considered a unit with operable access to the living areas of the unit, on two opposite aspects of the development.

10.4 State Environmental Planning Policy (SEPP65)

SEPP 65 defines that a development to be considered naturally ventilated, it is required that 60% of the units of the development be naturally ventilated. For a unit to be considered naturally ventilated, it is required that they perform to the minimum performance of the double-end units or corner units of the development. A double-ended unit is considered a unit with operable access to the living areas of the units on two opposite aspects of the development. It should be noted that due to external and/or internal obstructions potentially reducing the effectiveness of a double-end or corner unit, a lower-end limit of 0.4m/s has been incorporated to ensure sufficient occupant comfort.

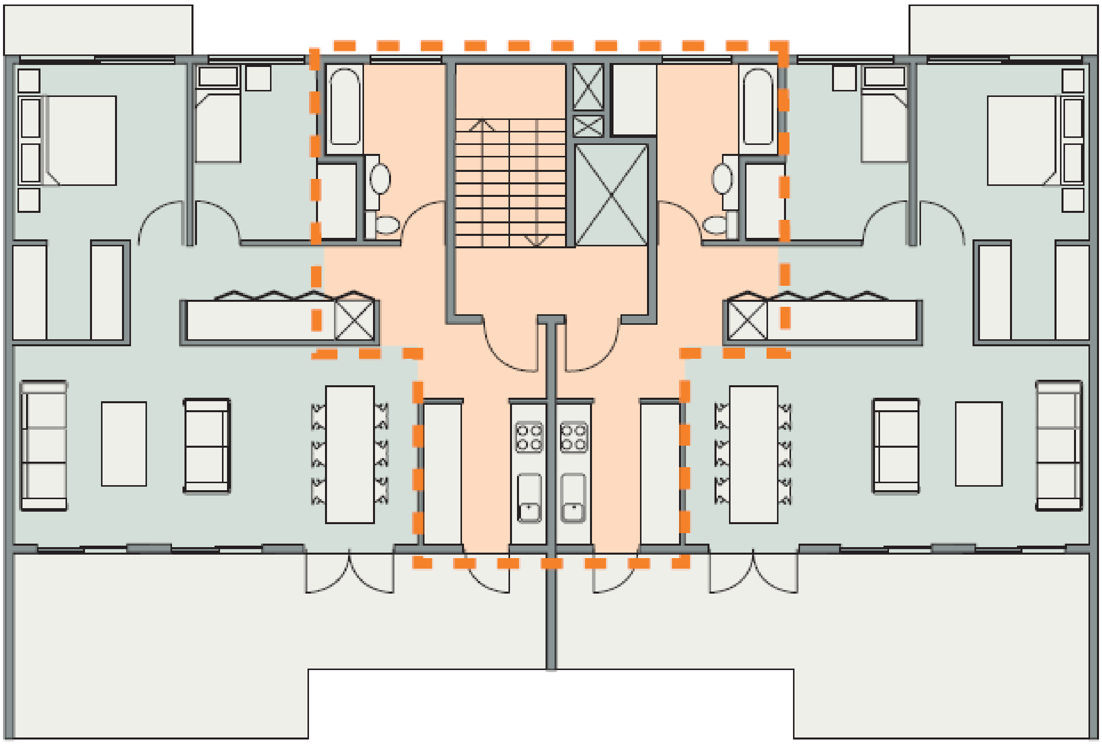

Figure 7b. Living Spaces of a Typical Unit (SEPP 65 RFDC, 2002)

For each of the abovementioned criteria, this based on the mean wind speed for the respectively wind direction. However, the percentage of occurrence of above a required wind speed from each wind direction to achieve the recommended criteria is also critical. As wind events are not consistent from each direction, this information has been taken into account. As such the residential units are deemed to be naturally ventilated should it meet the required criteria for more than 50% of the time.

11.0 Results of Study

A detailed study of the natural ventilation performance of the residential units of Macquarie Place development has been undertaken. A total 367 units have been investigated as part of this study.

The residential units of the development consist of corner, double ended and single aspect units. Due to the various possible configurations that could be achieved for each unit depending on window openings configuration, up to 4 critical flow paths through the living space of the units have been investigated. The unit layout for the two buildings and the specified internal flows paths are shown in Appendix C of this report. It has been considered for this study that the occupants of the residential units would not necessarily know how much to open specific windows in order to achieve more optimal ventilation. As such, it has been considered that a window is either completely open or completely closed as part of this study.

The criteria state that the natural ventilation flow through the corner rooms should meet a minimum daily average of 2 ACH for air quality in the room, and a desired airflow that is equivalent to the worst corner or double ended unit for the development. For this development, an airflow of 0.4 m/s is required to be met, based on the results of the study which found that Units 3.06 AND 4.06 to be the worst performing corner unit. This airflow is determined from a nominal area along the flow path where the occupant of the apartment would be able to experience the air flow. If an occupant would like to experience a large air flow, their instinct would be to move towards an opening where the air flow would be more apparent.

The performance of the units of the development is reliant of the pressure potential between the various windows for each unit. As such, units which are either located on the corners of the building, with two different aspects or units with stepped in balconies are more capable of producing the pressure potential required for natural ventilation. Section 10 of this report describes the general requirements of ACH and recommended flow velocity through a room for natural ventilation.

For each of the units of the development, the window size openings vary depending on the building and the unit layout. As such, the window opening sizes that have been proposed to be used have been included in Appendix B.

11.1 Natural Ventilation Performance of the Corner Units

This study consists of all of the units of the Macquarie Place development. Each of these buildings consists of numerous corner or double ended units located on the corner of each of the four blocks of the tower of the development on the various levels of the development. This development consists of self-contained units and not shared accommodation. As such, all windows of the unit can be considered to be accessible to the occupant of the unit and utilised for natural ventilation purposes. The window openings located or attached to the bathroom areas have not been included in this study as this is an area that may be closed off during use, for privacy or to avoid unwanted smells spreading through the apartment.

From the study, it was found that the worse-performing corner unit was Units 3.06 and 4.06. These unit achieve an air speed of 0.4m/s through the living space of the unit and in excess of the required 2 ACH. As such, the required criteria for the remaining units will be 2 ACH based on the requirements of the standards for air quality and 0.4m/s for airflow through the unit.

11.2 Natural Ventilation Performance of All of the Apartments

The development consists of numerous single aspect units located in primarily in Blocks B, C and D of the development. These single aspect units are located on the east and west aspect of blocks B and C, and the north and south aspects of block D. Four double end units are proposed on the upper levels of block D of the development.

As discussed in Section 10 of this report, the required criteria to satisfy the requirements for natural ventilation for SEPP65 are 2 ACH and an internal airflow velocity through the living space of 0.40m/s. It was found from the results of the study, that **without the inclusion of any of the ventilation air shafts being considered**, 65% (240 out of 367) of the units will satisfy the requirements for natural ventilation. Note, that for a development to be considered naturally ventilated, 60% of units for the entire development need to be considered naturally ventilated, that is meet the required criteria. Therefore, based on the latest design of the development, the requirements for natural ventilation will be satisfied.

Table 5: Natural Ventilation Performance

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
2.01	0.20	74%	NO
2.02	0.33	59%	NO
2.03	0.32	64%	NO
2.04	0.21	82%	NO
2.05	0.25	79%	NO
2.06	0.35	85%	NO
2.07	0.26	81%	NO
2.08	0.71	85%	YES
2.09	0.71	85%	YES
2.10	0.42	61%	YES
2.11	0.45	73%	YES
2.12	0.50	82%	YES
3.01	0.35	74%	NO
3.02	0.33	59%	NO
3.03	0.32	65%	NO
3.04	0.92	85%	YES

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
3.05	0.56	83%	YES
3.06	0.70	77%	YES
3.07	0.21	82%	NO
3.08	0.25	79%	NO
3.09	0.35	85%	NO
3.10	0.26	81%	NO
3.11	0.71	85%	YES
3.12	0.71	85%	YES
3.13	0.42	61%	YES
3.14	0.45	73%	YES
3.15	0.50	82%	YES
4.01	0.27	48%	NO
4.02	0.32	66%	NO
4.03	0.38	77%	NO
4.04	0.90	84%	YES
4.05	0.56	83%	YES
4.06	0.70	77%	YES
4.07	0.39	70%	NO
4.08	0.61	85%	YES
4.09	0.32	80%	NO
4.10	0.72	80%	YES
4.11	0.48	82%	YES
4.12	0.49	76%	YES
4.13	0.24	77%	NO
4.14	0.21	79%	NO
4.15	0.38	83%	NO
4.16	0.27	81%	NO
4.17	0.71	85%	YES
4.18	0.71	85%	YES
4.19	0.32	41%	NO
4.20	0.52	83%	YES

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
4.21	0.48	83%	YES
5.01	0.27	48%	NO
5.02	0.32	66%	NO
5.03	0.38	77%	NO
5.04	0.90	84%	YES
5.05	0.56	83%	YES
5.06	0.70	77%	YES
5.07	0.39	70%	NO
5.08	0.61	85%	YES
5.09	0.32	80%	NO
5.10	0.72	80%	YES
5.11	0.48	82%	YES
5.12	0.49	76%	YES
5.13	0.24	77%	NO
5.14	0.21	79%	NO
5.15	0.38	83%	NO
5.16	0.27	81%	NO
5.17	0.71	85%	YES
5.18	0.71	85%	YES
5.19	0.32	41%	NO
5.20	0.52	83%	YES
5.21	0.48	83%	YES
6.01	0.35	81%	NO
6.02	0.37	70%	NO
6.03	0.34	66%	NO
6.04	1.00	85%	YES
6.05	0.35	77%	NO
6.06	0.75	82%	YES
6.07	0.33	70%	NO
6.08	0.44	73%	YES
6.09	0.31	68%	NO

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
6.10	0.48	69%	YES
6.11	0.54	75%	YES
6.12	0.52	70%	YES
6.13	0.39	76%	NO
6.14	0.41	80%	YES
6.15	0.41	80%	YES
6.16	0.33	76%	NO
6.17	0.80	85%	YES
6.18	0.80	85%	YES
6.19	0.32	43%	NO
6.20	0.57	83%	YES
6.21	0.47	83%	YES
7.01	0.35	81%	NO
7.02	0.37	70%	NO
7.03	0.34	66%	NO
7.04	1.00	85%	YES
7.05	0.35	77%	NO
7.06	0.75	82%	YES
7.07	0.33	70%	NO
7.08	0.44	73%	YES
7.09	0.31	68%	NO
7.10	0.48	69%	YES
7.11	0.54	75%	YES
7.12	0.52	70%	YES
7.13	0.39	76%	NO
7.14	0.41	80%	YES
7.15	0.41	80%	YES
7.16	0.33	76%	NO
7.17	0.80	85%	YES
7.18	0.80	85%	YES
7.19	0.32	43%	NO

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
7.20	0.57	83%	YES
7.21	0.47	83%	YES
8.01	0.35	81%	NO
8.02	0.37	70%	NO
8.03	0.34	66%	NO
8.04	1.00	85%	YES
8.05	0.35	77%	NO
8.06	0.75	82%	YES
8.07	0.33	70%	NO
8.08	0.44	73%	YES
8.09	0.31	68%	NO
8.10	0.48	69%	YES
8.11	0.54	75%	YES
8.12	0.52	70%	YES
8.13	0.39	76%	NO
8.14	0.41	80%	YES
8.15	0.41	80%	YES
8.16	0.33	76%	NO
8.17	0.80	85%	YES
8.18	0.80	85%	YES
8.19	0.32	43%	NO
8.20	0.57	83%	YES
8.21	0.47	83%	YES
9.01	0.40	79%	YES
9.02	0.34	70%	NO
9.03	0.34	66%	NO
9.04	1.00	85%	YES
9.05	0.40	77%	YES
9.06	0.75	82%	YES
9.07	0.33	68%	NO
9.08	0.44	73%	YES

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
9.09	0.31	68%	NO
9.10	0.48	69%	YES
9.11	0.48	75%	YES
9.12	0.54	75%	YES
9.13	0.29	54%	NO
9.14	0.49	80%	YES
9.15	0.49	80%	YES
9.16	1.36	82%	YES
9.17	0.98	85%	YES
9.18	0.33	68%	NO
9.19	1.01	85%	YES
9.20	1.01	85%	YES
9.21	0.80	85%	YES
9.22	0.80	85%	YES
9.23	0.32	43%	NO
9.24	0.57	83%	YES
9.25	0.47	83%	YES
10.01	0.40	79%	YES
10.02	0.34	70%	NO
10.03	0.34	66%	NO
10.04	1.00	85%	YES
10.05	0.40	77%	YES
10.06	0.75	82%	YES
10.07	0.33	68%	NO
10.08	0.44	73%	YES
10.09	0.31	68%	NO
10.10	0.48	69%	YES
10.11	0.48	75%	YES
10.12	0.54	75%	YES
10.13	0.44	72%	YES
10.14	0.57	83%	YES

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
10.15	0.47	83%	YES
11.01	0.40	79%	YES
11.02	0.34	70%	NO
11.03	0.34	66%	NO
11.04	1.00	85%	YES
11.05	0.40	77%	YES
11.06	0.75	82%	YES
11.07	0.33	68%	NO
11.08	0.44	73%	YES
11.09	0.31	68%	NO
11.10	0.48	69%	YES
11.11	0.48	75%	YES
11.12	0.54	75%	YES
11.13	0.95	85%	YES
11.14	0.45	81%	YES
11.15	0.57	81%	YES
12.01	0.55	83%	YES
12.02	0.34	76%	NO
12.03	0.31	57%	NO
12.04	1.06	85%	YES
12.05	0.32	71%	NO
12.06	0.76	84%	YES
12.07	0.41	65%	YES
12.08	0.48	75%	YES
12.09	0.19	45%	NO
12.10	0.21	52%	NO
12.11	0.43	72%	YES
12.12	0.58	74%	YES
12.13	0.45	81%	YES
12.14	0.57	81%	YES
13.01	0.55	83%	YES

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
13.02	0.34	76%	NO
13.03	0.31	57%	NO
13.04	1.06	85%	YES
13.05	0.32	71%	NO
13.06	0.76	84%	YES
13.07	0.41	65%	YES
13.08	0.48	75%	YES
13.09	0.19	45%	NO
13.10	0.21	52%	NO
13.11	0.43	72%	YES
13.12	0.58	74%	YES
13.13	0.62	85%	YES
13.14	0.59	82%	YES
13.15	0.46	78%	YES
13.16	0.57	81%	YES
14.01	0.55	83%	YES
14.02	0.34	76%	NO
14.03	0.31	57%	NO
14.04	1.06	85%	YES
14.05	0.32	71%	NO
14.06	0.76	84%	YES
14.07	0.41	65%	YES
14.08	0.48	75%	YES
14.09	0.19	45%	NO
14.10	0.21	52%	NO
14.11	0.43	72%	YES
14.12	0.58	74%	YES
14.13	0.62	85%	YES
14.14	0.59	82%	YES
14.15	0.46	78%	YES
14.16	0.57	81%	YES

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
15.01	0.55	83%	YES
15.02	0.34	76%	NO
15.03	0.31	57%	NO
15.04	1.06	85%	YES
15.05	0.32	71%	NO
15.06	0.76	84%	YES
15.07	0.41	65%	YES
15.08	0.48	75%	YES
15.09	0.19	45%	NO
15.10	0.21	52%	NO
15.11	0.43	72%	YES
15.12	0.58	74%	YES
15.13	0.62	85%	YES
15.14	0.59	82%	YES
15.15	0.46	78%	YES
15.16	0.57	81%	YES
16.01	0.62	82%	YES
16.02	0.39	71%	YES
16.03	0.31	60%	NO
16.04	1.03	82%	YES
16.05	0.28	70%	NO
16.06	0.88	85%	YES
16.07	0.42	73%	YES
16.08	0.41	52%	YES
16.09	0.19	44%	NO
16.10	0.23	51%	NO
16.11	0.44	72%	YES
16.12	0.64	80%	YES
16.13	0.62	84%	YES
16.14	0.57	81%	YES
16.15	0.44	80%	YES

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
16.16	0.63	74%	YES
17.01	0.62	82%	YES
17.02	0.39	71%	YES
17.03	0.31	60%	NO
17.04	1.03	82%	YES
17.05	0.28	70%	NO
17.06	0.88	85%	YES
17.07	0.42	73%	YES
17.08	0.41	52%	YES
17.09	0.19	44%	NO
17.10	0.23	51%	NO
17.11	0.44	72%	YES
17.12	0.64	80%	YES
17.13	0.62	84%	YES
17.14	0.57	81%	YES
17.15	0.44	80%	YES
17.16	0.63	74%	YES
18.01	0.62	82%	YES
18.02	0.39	71%	YES
18.03	0.31	60%	NO
18.04	1.03	82%	YES
18.05	0.28	70%	NO
18.06	0.88	85%	YES
18.07	0.42	73%	YES
18.08	0.41	52%	YES
18.09	0.19	44%	NO
18.10	0.23	51%	NO
18.11	0.44	72%	YES
18.12	0.64	80%	YES
18.13	0.62	84%	YES
18.14	0.57	81%	YES

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
18.15	0.44	80%	YES
18.16	0.63	74%	YES
19.01	0.69	79%	YES
19.02	0.42	80%	YES
19.03	0.32	66%	NO
19.04	1.08	83%	YES
19.05	0.30	58%	NO
19.06	0.96	85%	YES
19.07	0.53	69%	YES
19.08	0.43	67%	YES
19.09	0.23	50%	NO
19.10	0.22	46%	NO
19.11	0.39	64%	NO
19.12	0.64	80%	YES
19.13	0.69	85%	YES
19.14	0.51	83%	YES
19.15	0.44	72%	YES
19.16	0.74	84%	YES
20.01	0.69	79%	YES
20.02	0.42	80%	YES
20.03	0.32	66%	NO
20.04	1.08	83%	YES
20.05	0.30	58%	NO
20.06	0.96	85%	YES
20.07	0.53	69%	YES
20.08	0.43	67%	YES
20.09	0.23	50%	NO
20.10	0.22	46%	NO
20.11	0.39	64%	NO
20.12	0.64	80%	YES

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
20.13	0.69	85%	YES
20.14	0.51	83%	YES
20.15	0.44	72%	YES
20.16	0.74	84%	YES
21.01	0.69	79%	YES
21.02	0.42	80%	YES
21.03	0.32	66%	NO
21.04	1.08	83%	YES
21.05	0.30	58%	NO
21.06	0.96	85%	YES
21.07	0.53	69%	YES
21.08	0.43	67%	YES
21.09	0.23	50%	NO
21.10	0.68	75%	YES
21.11	0.62	73%	YES
21.12	0.56	77%	YES
21.13	0.74	81%	YES
22.01	0.45	74%	YES
22.02	0.37	73%	NO
22.03	0.39	64%	YES
22.04	1.14	83%	YES
22.05	0.35	66%	NO
22.06	1.02	84%	YES
22.07	0.28	67%	NO
22.08	0.47	83%	YES
22.09	0.42	69%	YES
23.01	0.45	74%	YES
23.02	0.37	73%	NO
23.03	0.39	64%	YES
23.04	1.14	83%	YES

Table 5: Natural Ventilation Performance (cont..)

Apartment Number	Weighted Air Flow Through The Apartment (m/s)	Percentage of Time Above ACH Criteria	Complies
23.05	0.35	66%	NO
23.06	1.02	84%	YES
23.07	0.28	67%	NO
23.08	0.47	83%	YES
23.09	0.42	69%	YES
24.01	0.52	68%	YES
24.02	0.65	81%	YES
24.03	1.52	84%	YES
24.04	0.60	61%	YES
24.05	0.99	83%	YES
24.06	0.78	80%	YES
24.07	0.64	72%	YES

12.0 Conclusion

A detailed investigation has been undertaken into the natural ventilation performance of the residential units of the proposed development known as Macquarie Place, located in Parramatta.

The Australian Standard AS1668.2-2002 requires a minimum of 2 ACH for air quality due to occupant related contaminants. Also to address the requirements of SEPP65, a benchmark was set for airflow velocity through a window of the main living space based on the performance of the least-performing corner or double ended unit, which in this development achieved a directionally weighted average velocity of 0.4m/s.

The development consists of numerous single aspect units located in primarily in blocks B, C and D of the development. These single aspect units are located on the east and west aspect of Blocks B and C, and the north and south aspects of block D. Four double ended units are proposed on the upper levels of block D of the development.

The internal layout of each unit was also taken into account to verify that the living areas of the various residential dwellings achieve adequate ventilation. The analysis also takes into account the affects of any internal openings on the flow potential through the units.

The results of the study for the current scheme indicates that without the inclusion of the proposed ventilation shafts, 65% of the residential apartments would achieve a natural ventilation performance equivalent to or better than a SEPP65 deemed to comply dwelling. The single aspect dwellings have been able to achieve adequate natural ventilation due to the stepped façade design with the external aspect located on the perimeter of the building envelope, the location of openings with respect to the prevailing breezes and the internal layout.

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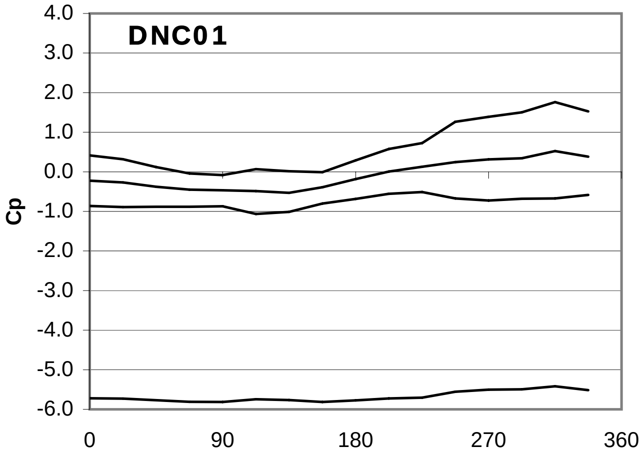
Appendix A

Plots of Wind Tunnel Results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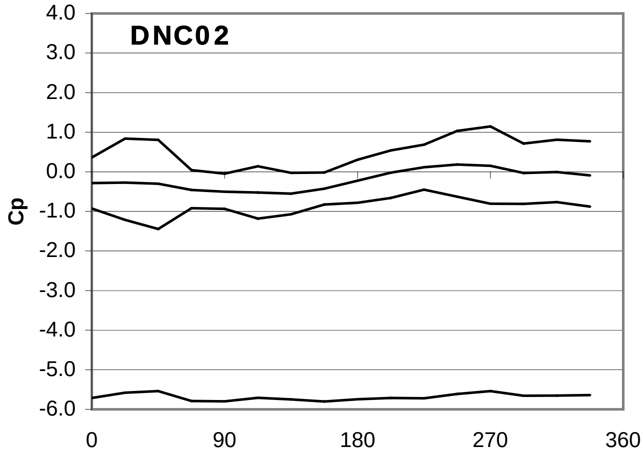
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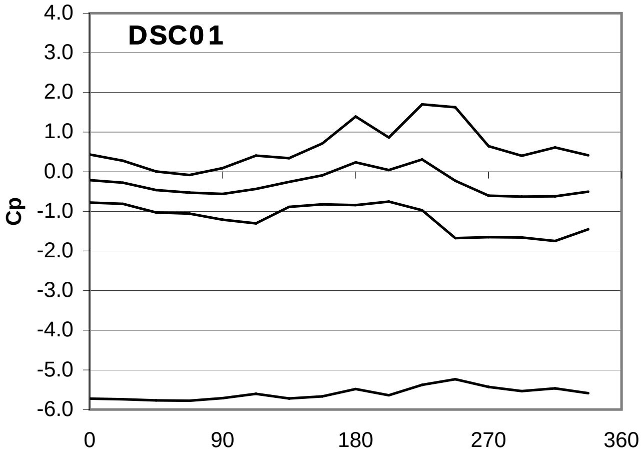
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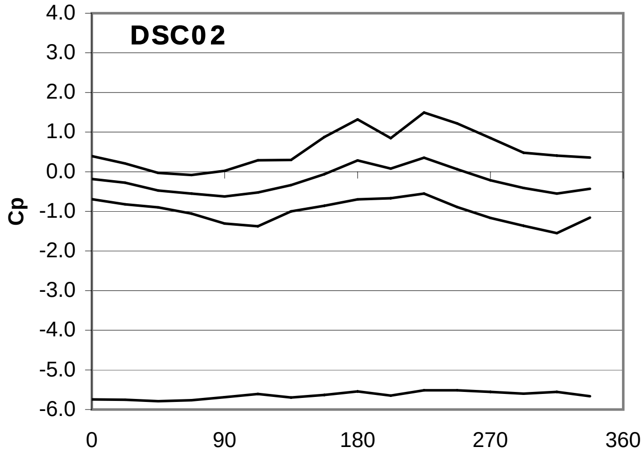
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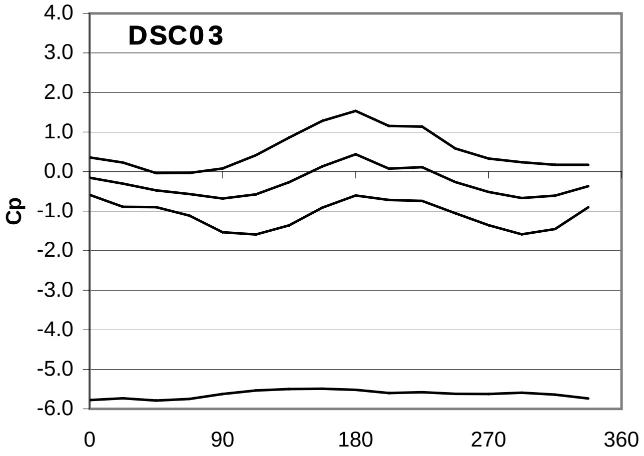
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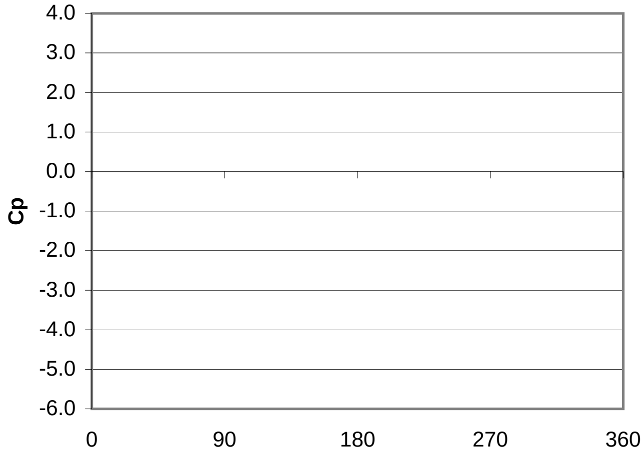
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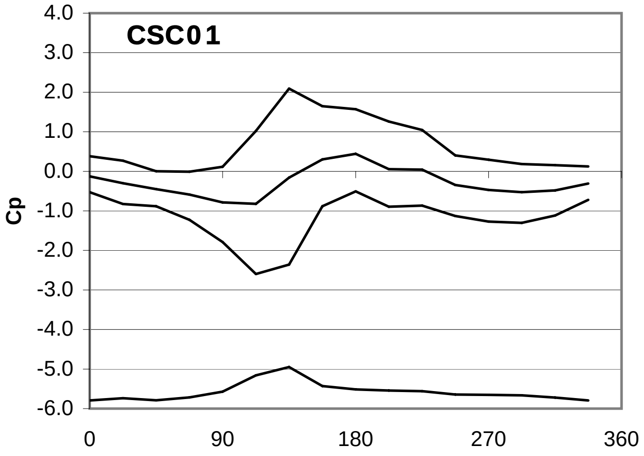
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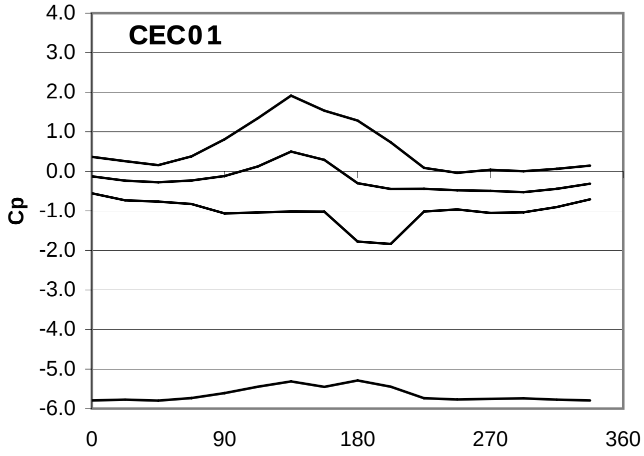
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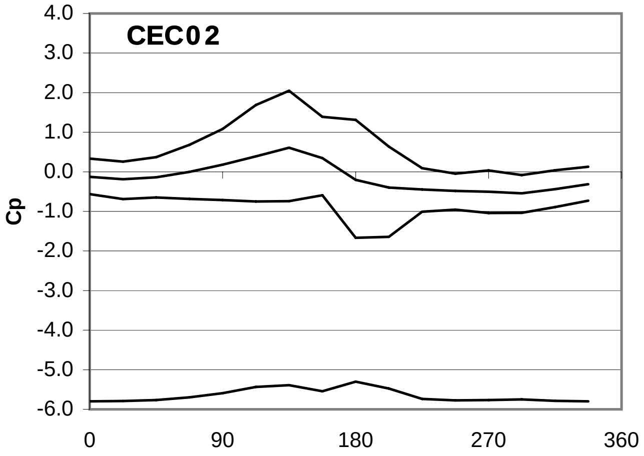
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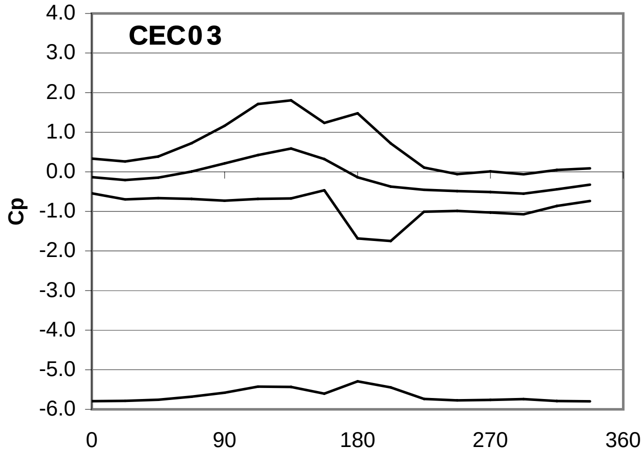
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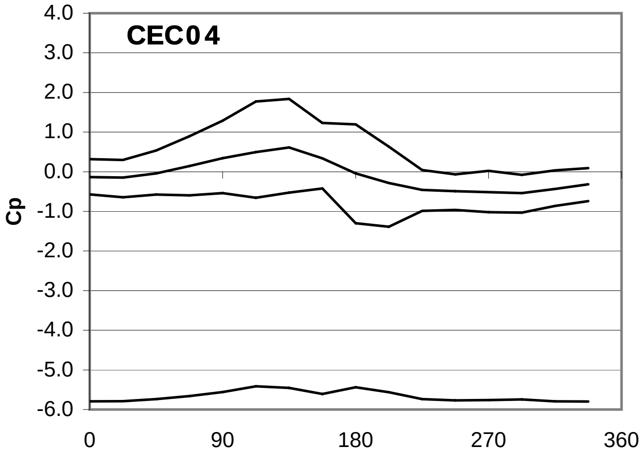
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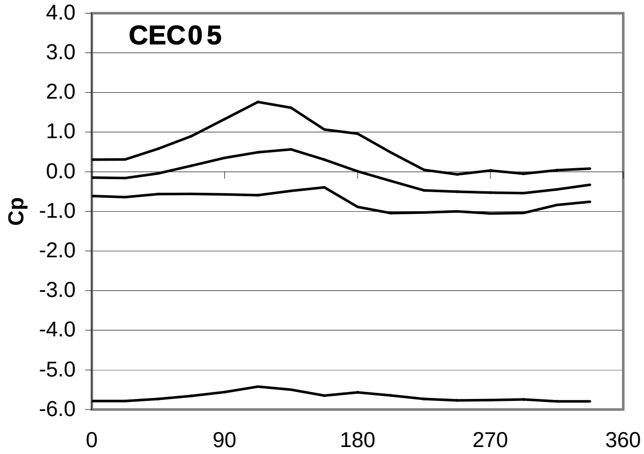
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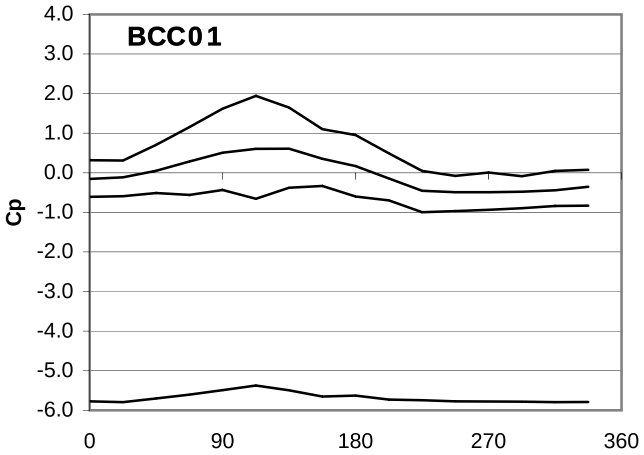
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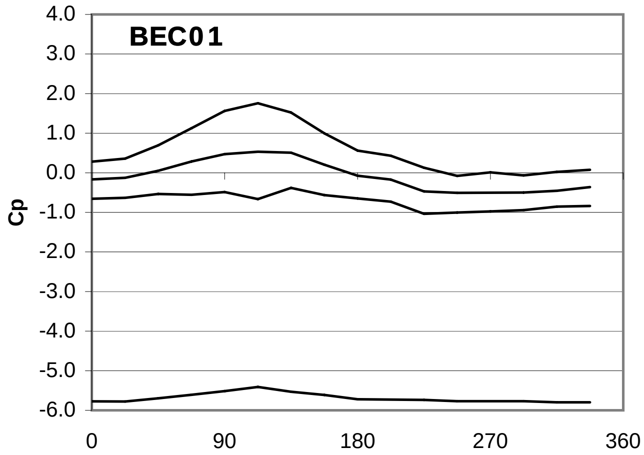
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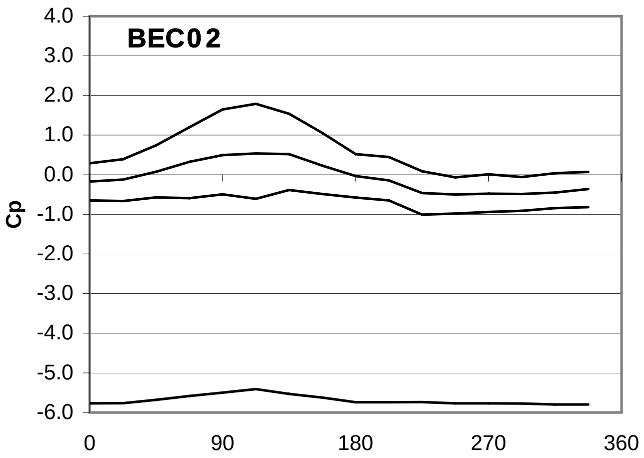
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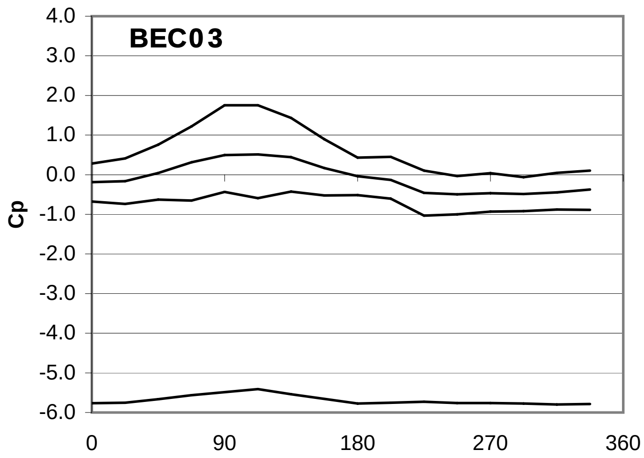
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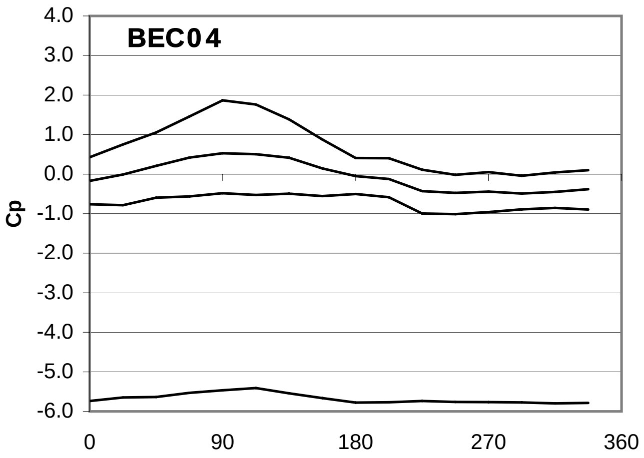
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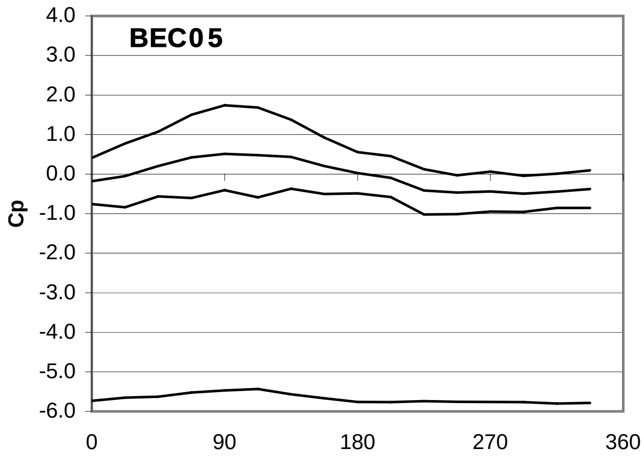
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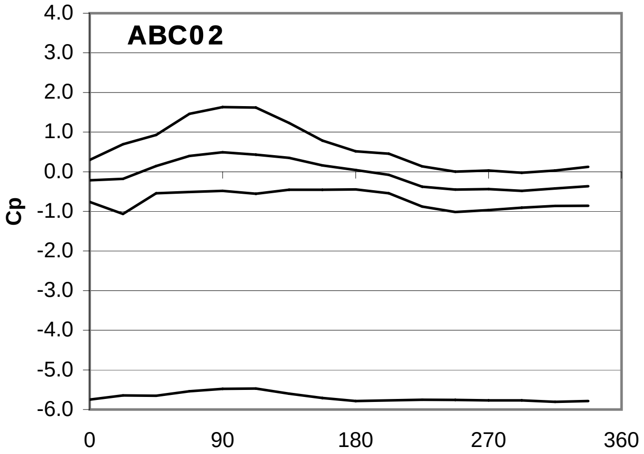
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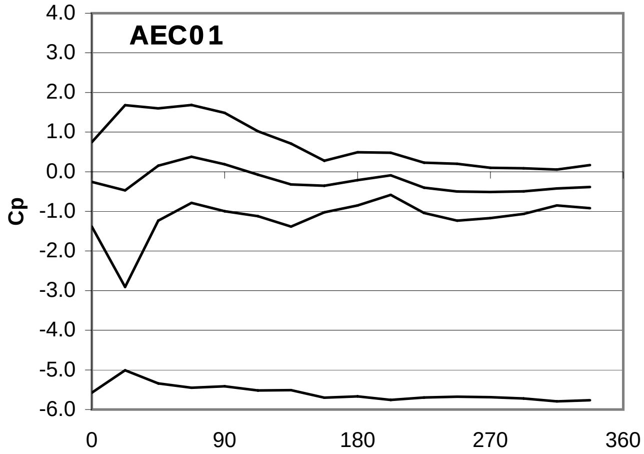
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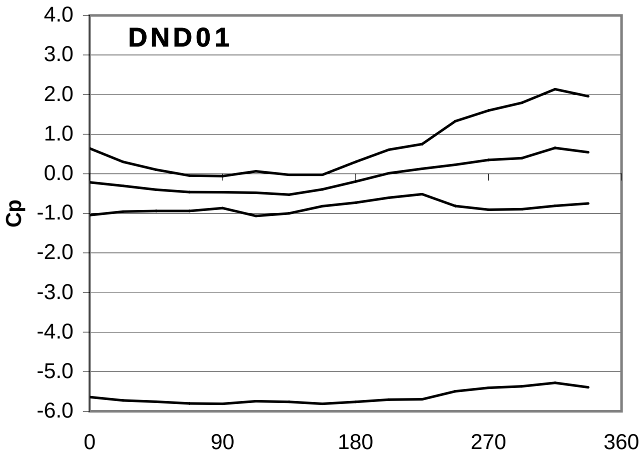
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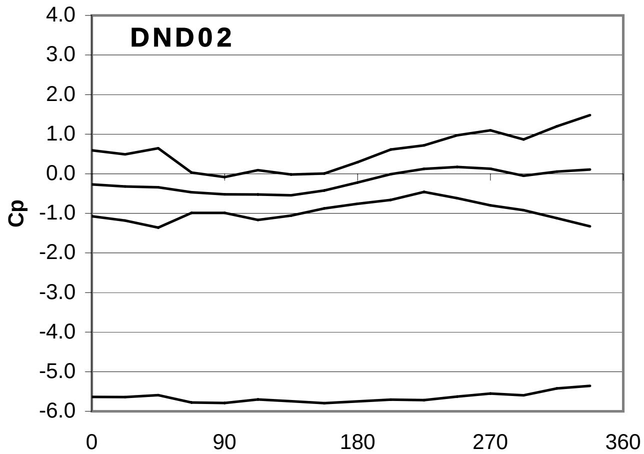
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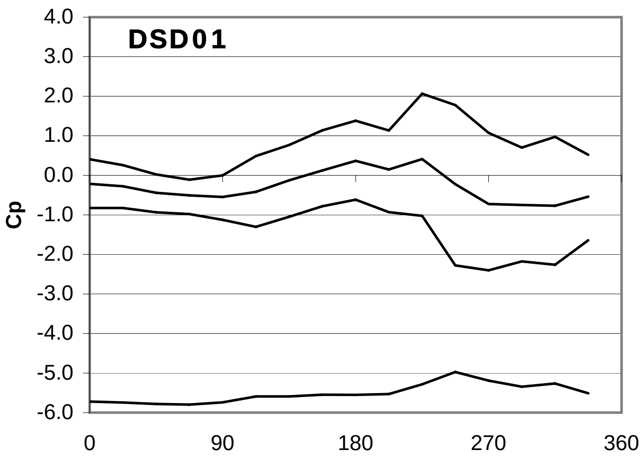
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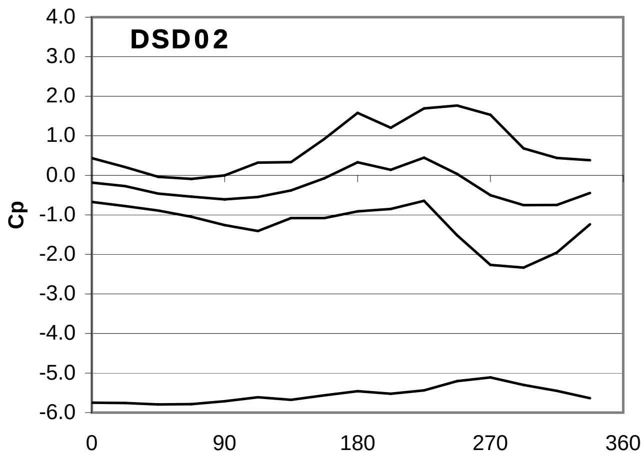
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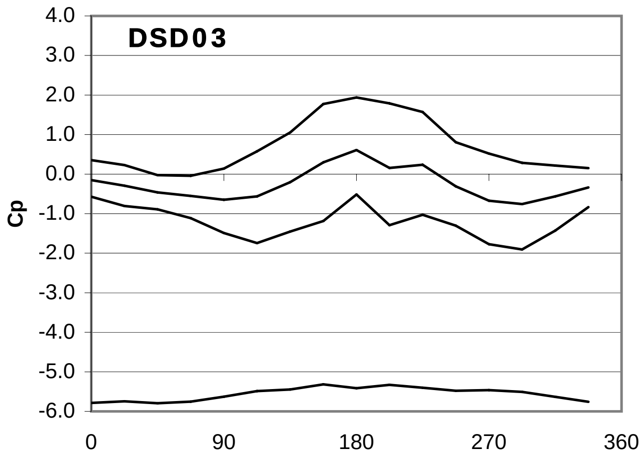
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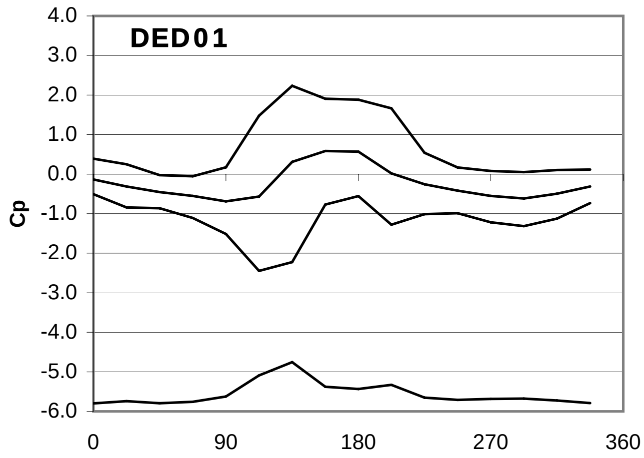
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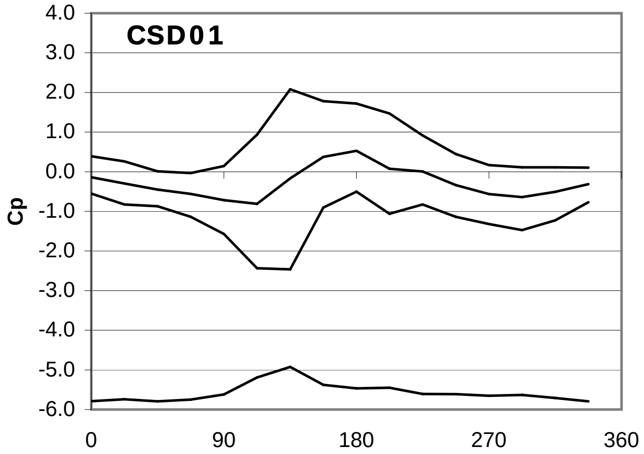
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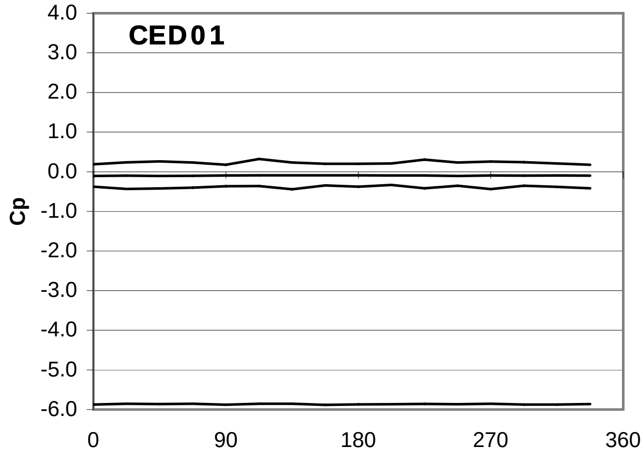
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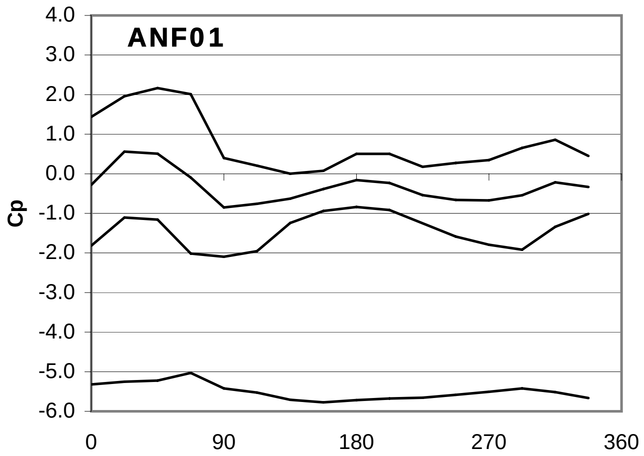
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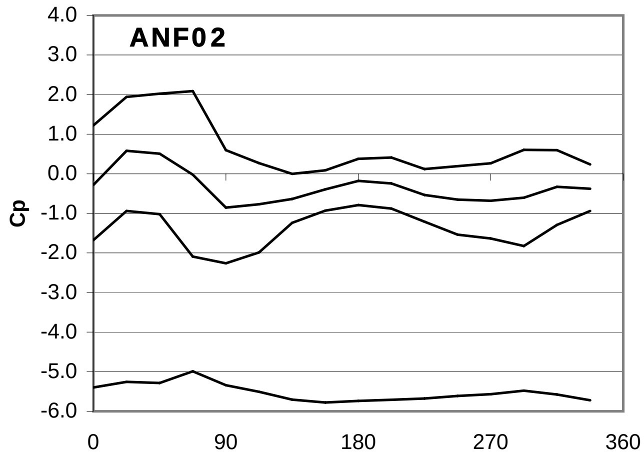
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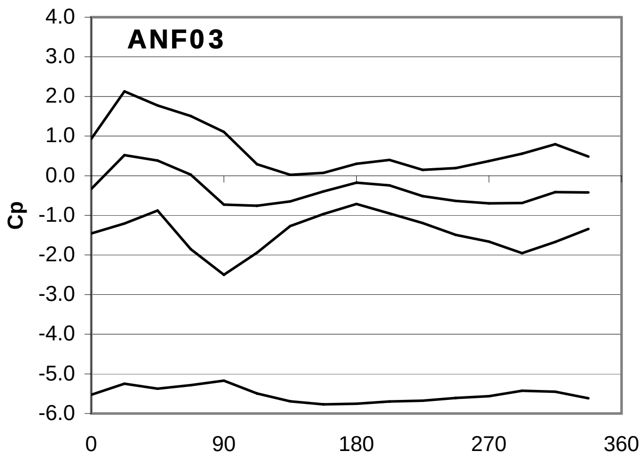
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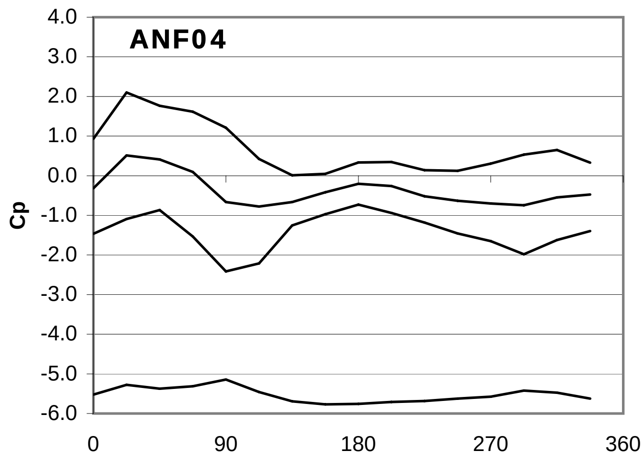
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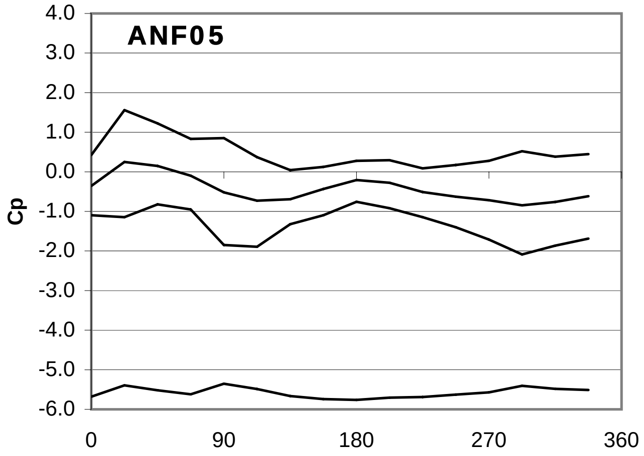
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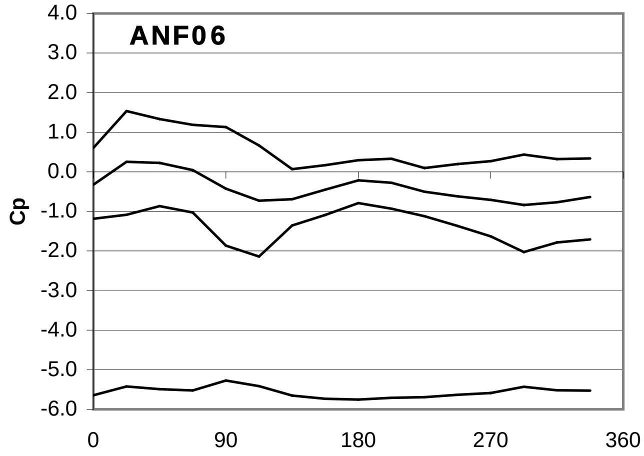
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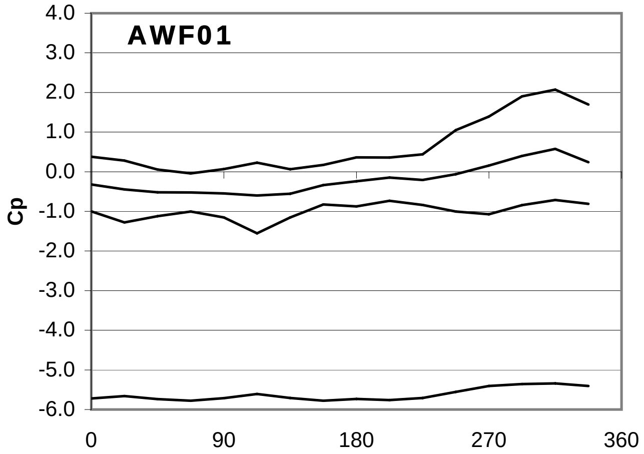
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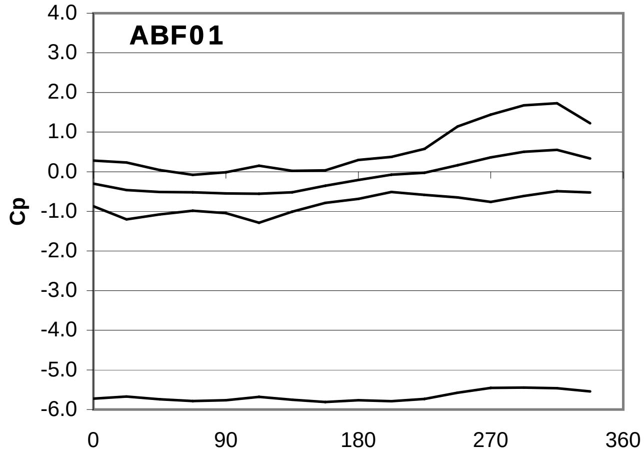
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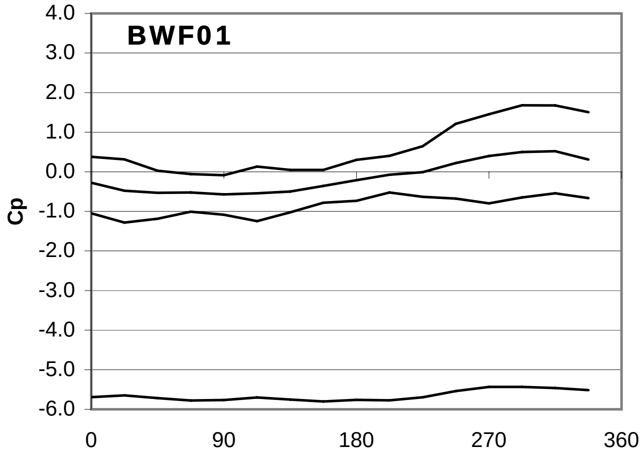
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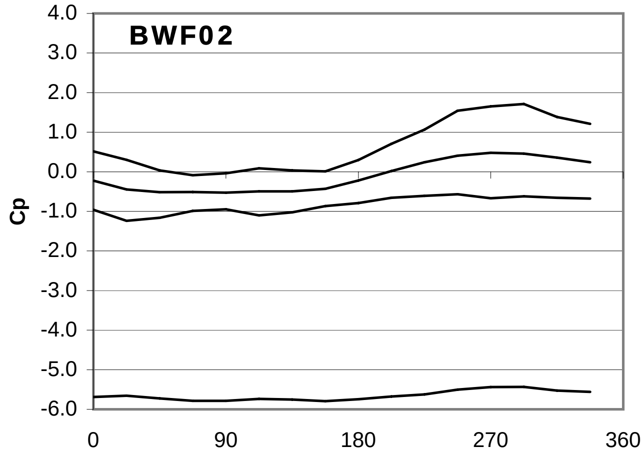
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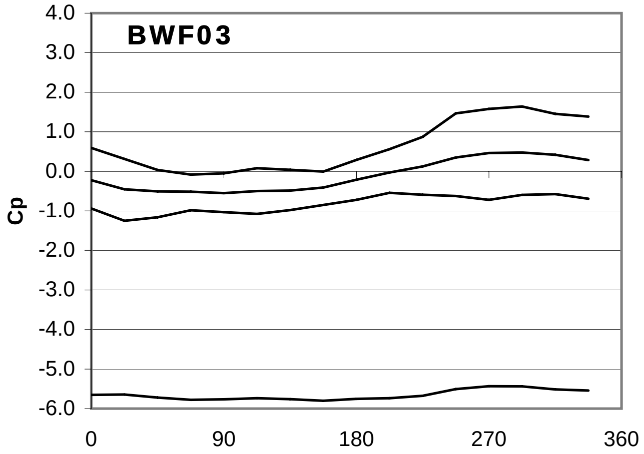
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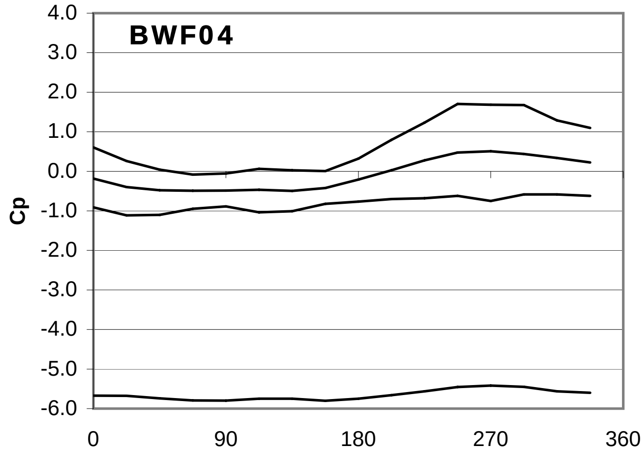
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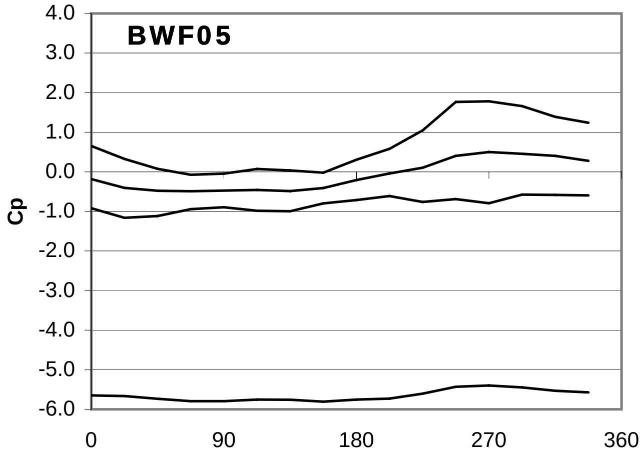
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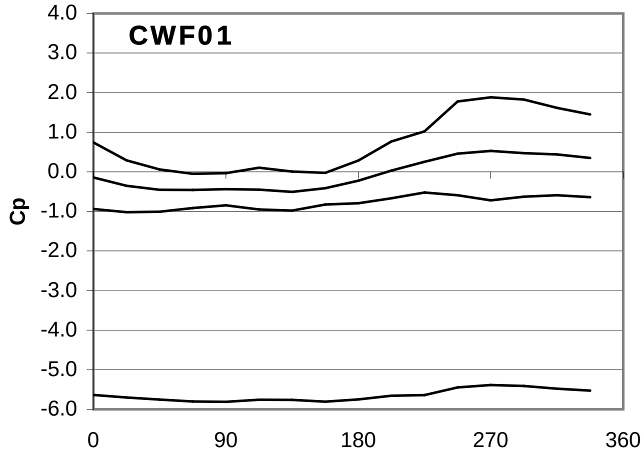
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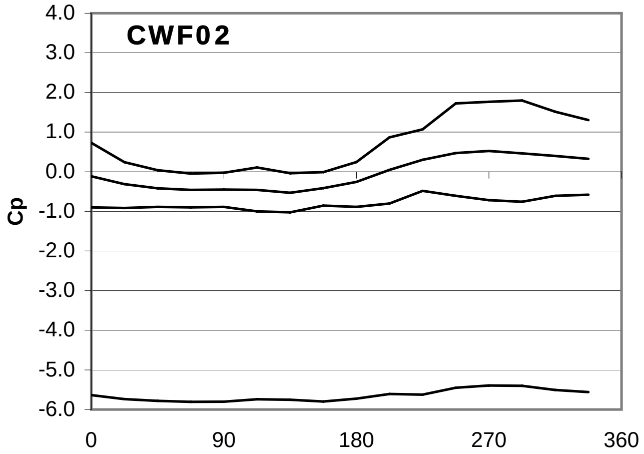
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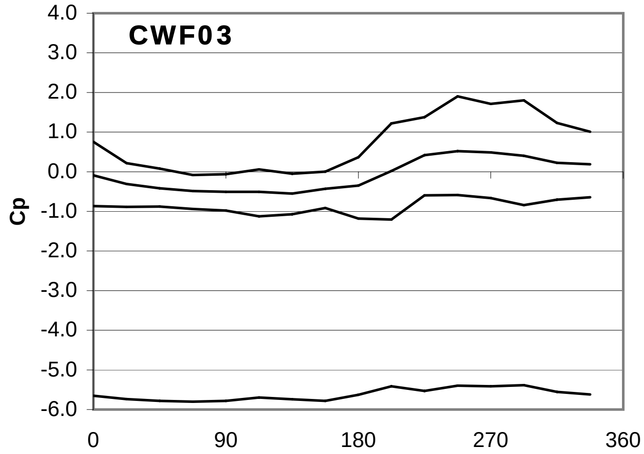
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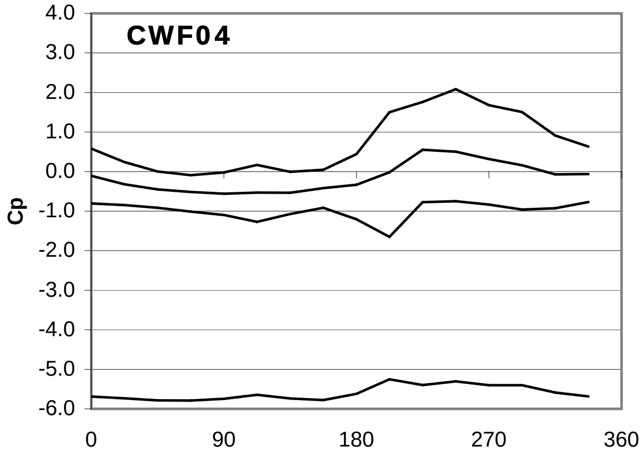
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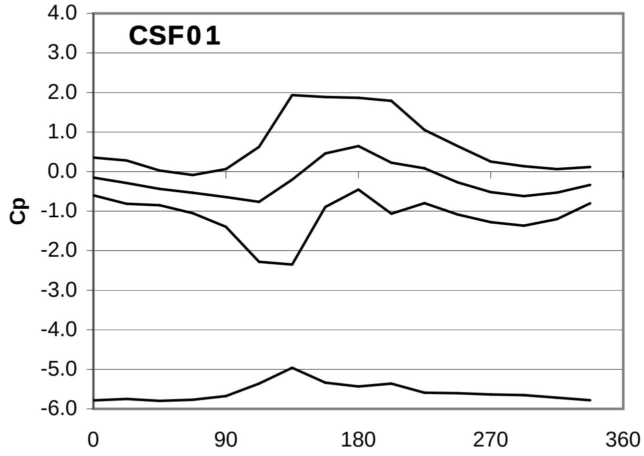
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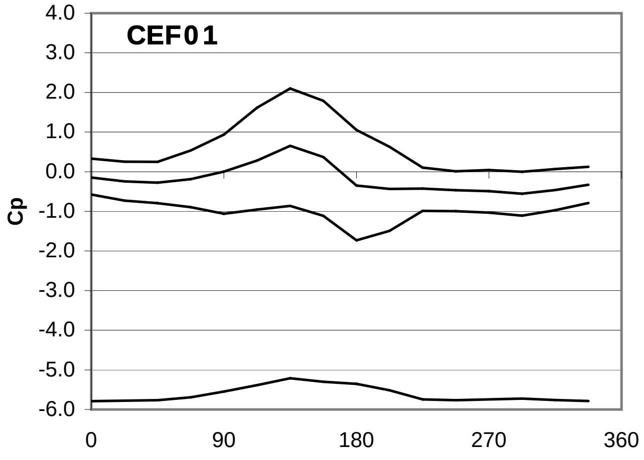
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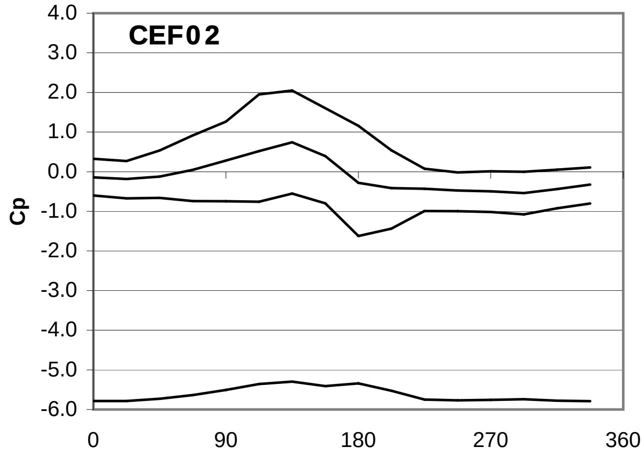
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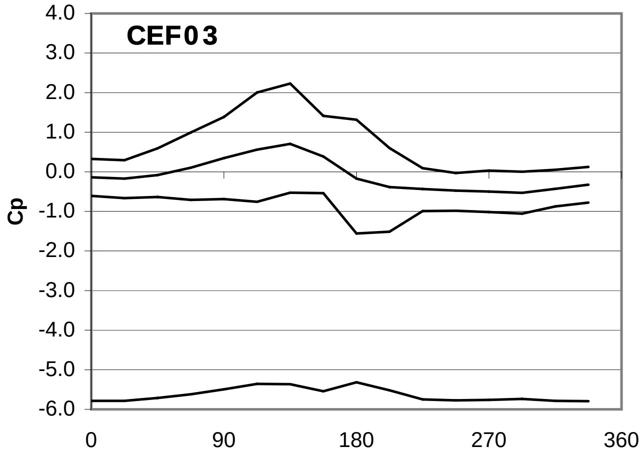
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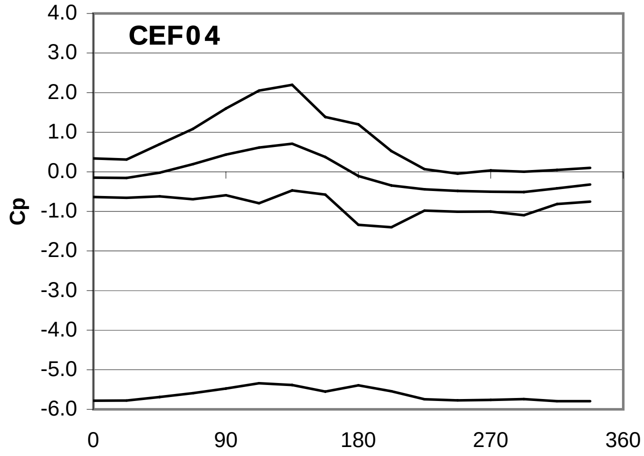
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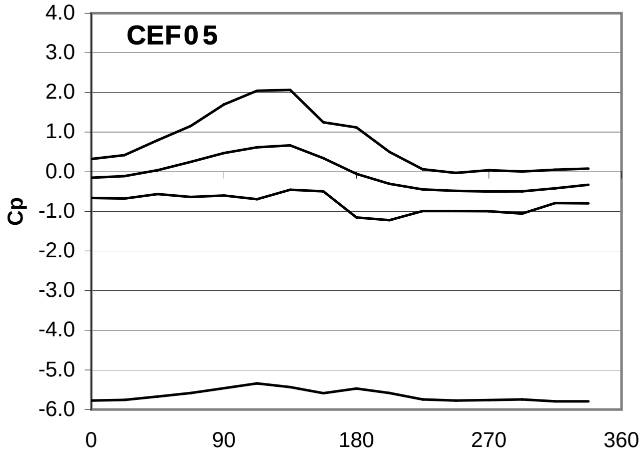
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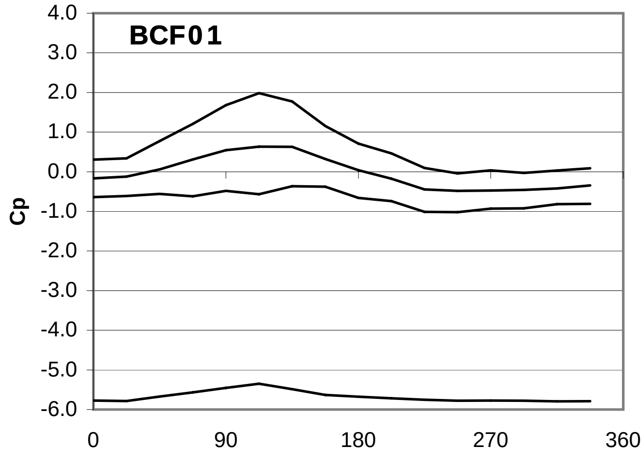
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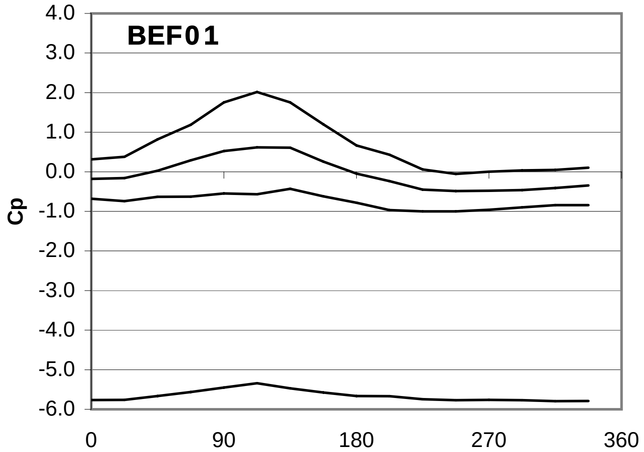
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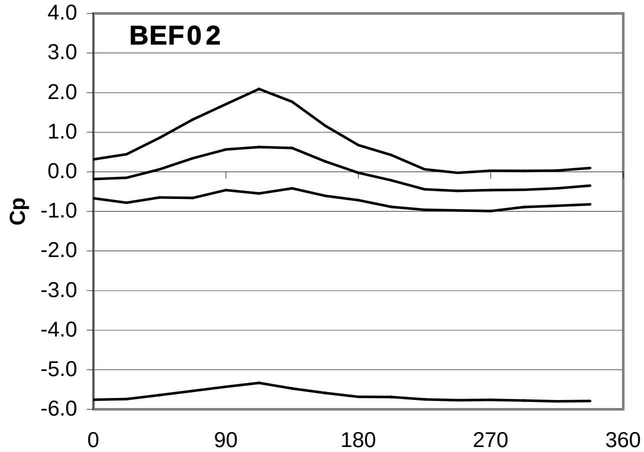
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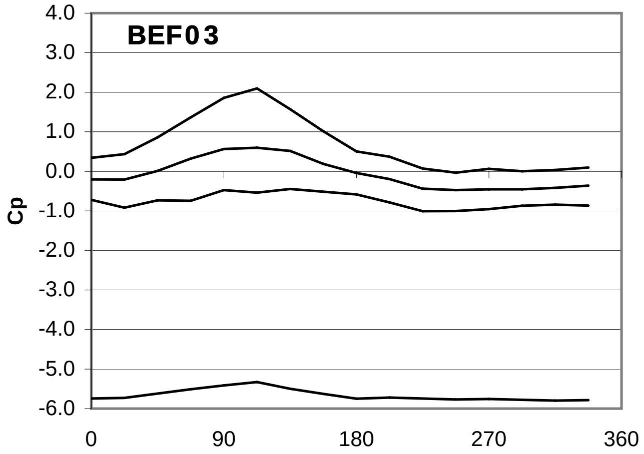
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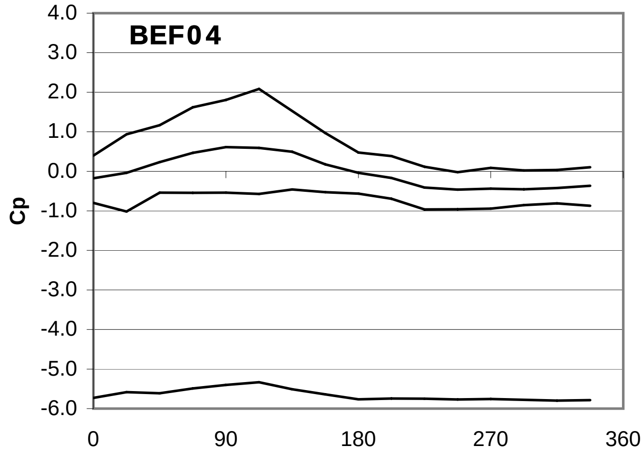
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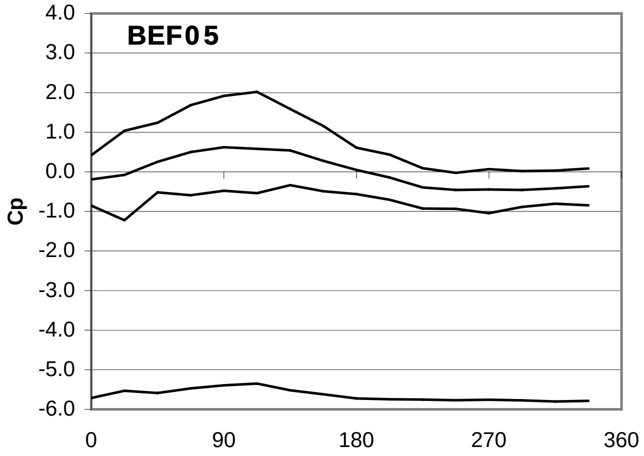
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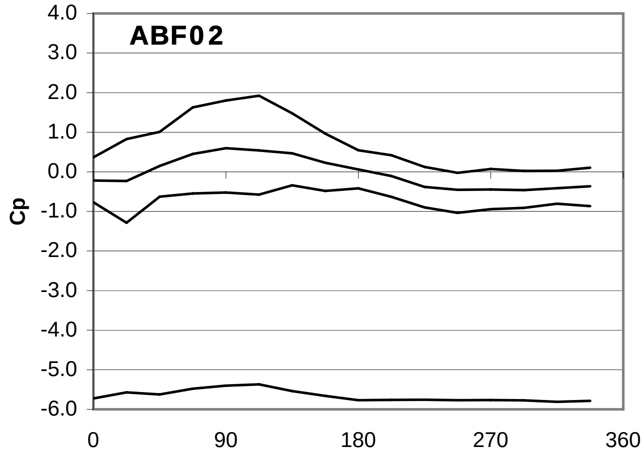
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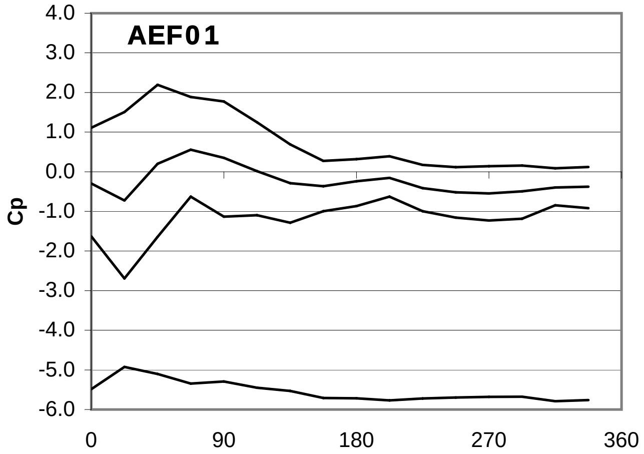
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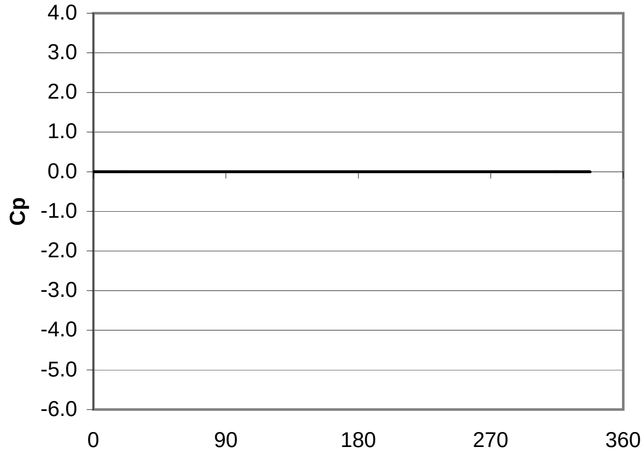
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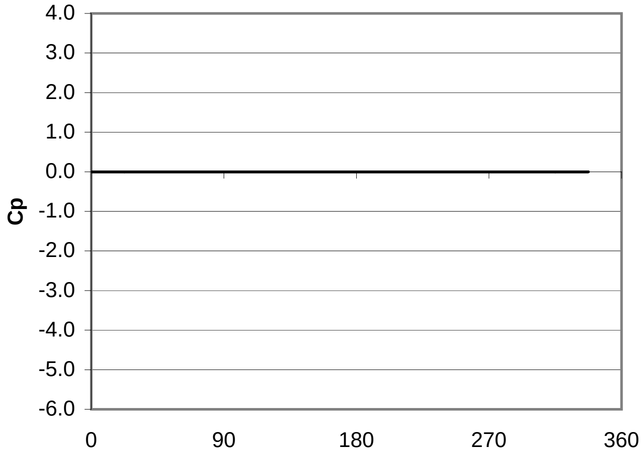
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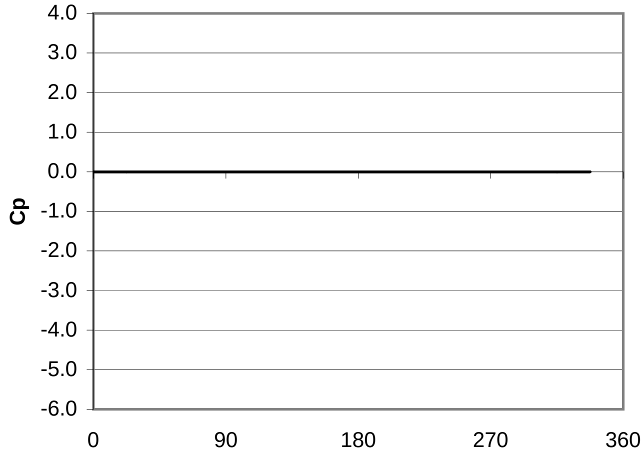
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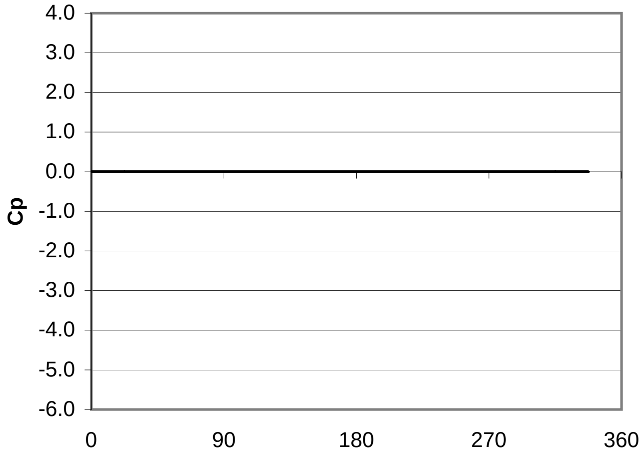
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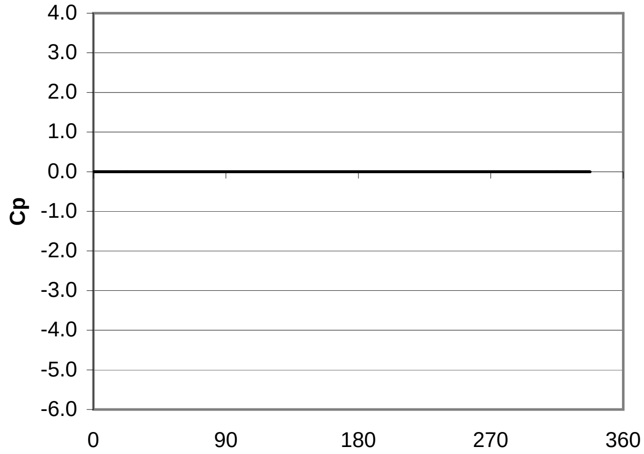
Cp
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0 90 180 270 360

Coefficient Plot Data

Plot	Data	0	22.5	45	67.5	90	112.5	135
Plot 01	Mean	-0.22	-0.27	-0.38	-0.45	-0.47	-0.49	-0.53
	Std Dev	-5.72	-5.73	-5.77	-5.81	-5.81	-5.75	-5.77
	Maximum	0.41	0.32	0.12	-0.04	-0.08	0.07	0.01
	Minimum	-0.86	-0.89	-0.88	-0.88	-0.87	-1.07	-1.01
Plot 02	Mean	-0.29	-0.27	-0.30	-0.46	-0.50	-0.52	-0.55
	Std Dev	-5.71	-5.58	-5.54	-5.79	-5.80	-5.71	-5.75
	Maximum	0.36	0.84	0.81	0.04	-0.05	0.14	-0.03
	Minimum	-0.93	-1.22	-1.44	-0.92	-0.94	-1.18	-1.07
Plot 03	Mean	-0.21	-0.28	-0.46	-0.53	-0.56	-0.43	-0.25
	Std Dev	-5.73	-5.74	-5.77	-5.78	-5.71	-5.61	-5.72
	Maximum	0.43	0.28	0.01	-0.08	0.09	0.41	0.34
	Minimum	-0.78	-0.81	-1.03	-1.06	-1.21	-1.30	-0.89
Plot 04	Mean	-0.18	-0.28	-0.47	-0.55	-0.62	-0.52	-0.34
	Std Dev	-5.75	-5.75	-5.79	-5.77	-5.69	-5.61	-5.70
	Maximum	0.40	0.21	-0.03	-0.08	0.02	0.29	0.30
	Minimum	-0.69	-0.82	-0.90	-1.05	-1.31	-1.38	-1.00
Plot 05	Mean	-0.15	-0.31	-0.47	-0.57	-0.68	-0.58	-0.27
	Std Dev	-5.78	-5.73	-5.79	-5.75	-5.63	-5.53	-5.50
	Maximum	0.36	0.23	-0.04	-0.04	0.08	0.41	0.86
	Minimum	-0.59	-0.89	-0.90	-1.11	-1.53	-1.59	-1.36
Plot 06	Mean	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	Std Dev	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	Maximum	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	Minimum	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Plot 07	Mean	-0.13	-0.30	-0.45	-0.59	-0.79	-0.82	-0.16
	Std Dev	-5.79	-5.74	-5.79	-5.72	-5.57	-5.16	-4.95
	Maximum	0.38	0.27	0.00	-0.01	0.11	1.02	2.09
	Minimum	-0.53	-0.83	-0.88	-1.23	-1.79	-2.60	-2.36
Plot 08	Mean	-0.13	-0.24	-0.28	-0.23	-0.12	0.12	0.50
	Std Dev	-5.79	-5.77	-5.80	-5.74	-5.61	-5.45	-5.31
	Maximum	0.37	0.26	0.16	0.38	0.81	1.35	1.92
	Minimum	-0.55	-0.73	-0.76	-0.83	-1.07	-1.04	-1.01
Plot 09	Mean	-0.13	-0.19	-0.14	0.00	0.18	0.39	0.61
	Std Dev	-5.80	-5.79	-5.77	-5.70	-5.59	-5.43	-5.39
	Maximum	0.33	0.26	0.37	0.68	1.08	1.69	2.05
	Minimum	-0.56	-0.69	-0.65	-0.69	-0.71	-0.75	-0.74
Plot 10	Mean	-0.14	-0.21	-0.15	0.01	0.21	0.42	0.59
	Std Dev	-5.79	-5.79	-5.76	-5.68	-5.58	-5.43	-5.44
	Maximum	0.33	0.26	0.39	0.72	1.16	1.71	1.81
	Minimum	-0.55	-0.70	-0.66	-0.68	-0.73	-0.68	-0.67
Plot 11	Mean	-0.13	-0.15	-0.04	0.14	0.34	0.50	0.61
	Std Dev	-5.79	-5.79	-5.74	-5.66	-5.56	-5.42	-5.45
	Maximum	0.32	0.30	0.54	0.89	1.29	1.77	1.84
	Minimum	-0.57	-0.64	-0.57	-0.60	-0.54	-0.66	-0.53
Plot 12	Mean	-0.15	-0.16	-0.04	0.15	0.35	0.49	0.57
	Std Dev	-5.79	-5.79	-5.73	-5.66	-5.56	-5.42	-5.50
	Maximum	0.31	0.31	0.58	0.90	1.33	1.76	1.62
	Minimum	-0.61	-0.64	-0.56	-0.56	-0.57	-0.59	-0.48
Plot 13	Mean	-0.16	-0.11	0.05	0.29	0.51	0.60	0.61
	Std Dev	-5.78	-5.79	-5.70	-5.60	-5.49	-5.37	-5.50
	Maximum	0.32	0.31	0.71	1.15	1.62	1.94	1.65
	Minimum	-0.61	-0.59	-0.51	-0.56	-0.44	-0.66	-0.38
	Mean	-0.17	-0.13	0.05	0.28	0.47	0.53	0.51

Plot 14	Std Dev	-5.77	-5.78	-5.70	-5.61	-5.52	-5.41	-5.53
	Maximum	0.28	0.36	0.69	1.13	1.56	1.76	1.52
	Minimum	-0.66	-0.63	-0.54	-0.56	-0.49	-0.66	-0.38
Plot 15	Mean	-0.17	-0.12	0.08	0.32	0.49	0.54	0.52
	Std Dev	-5.77	-5.76	-5.68	-5.58	-5.50	-5.41	-5.53
	Maximum	0.29	0.39	0.74	1.20	1.65	1.79	1.54
	Minimum	-0.65	-0.66	-0.57	-0.59	-0.49	-0.61	-0.38
Plot 16	Mean	-0.19	-0.16	0.04	0.31	0.50	0.51	0.44
	Std Dev	-5.76	-5.75	-5.67	-5.56	-5.49	-5.41	-5.54
	Maximum	0.28	0.41	0.76	1.22	1.75	1.75	1.43
	Minimum	-0.67	-0.74	-0.63	-0.65	-0.44	-0.59	-0.43
Plot 17	Mean	-0.17	-0.01	0.21	0.42	0.53	0.50	0.41
	Std Dev	-5.74	-5.65	-5.64	-5.53	-5.47	-5.41	-5.54
	Maximum	0.43	0.75	1.05	1.46	1.87	1.76	1.38
	Minimum	-0.76	-0.79	-0.60	-0.56	-0.48	-0.53	-0.49
Plot 18	Mean	-0.18	-0.05	0.21	0.42	0.51	0.48	0.43
	Std Dev	-5.73	-5.65	-5.63	-5.52	-5.47	-5.43	-5.57
	Maximum	0.41	0.77	1.07	1.50	1.74	1.69	1.38
	Minimum	-0.76	-0.84	-0.56	-0.60	-0.41	-0.59	-0.37
Plot 19	Mean	-0.21	-0.18	0.14	0.40	0.49	0.43	0.35
	Std Dev	-5.75	-5.64	-5.65	-5.54	-5.48	-5.47	-5.60
	Maximum	0.30	0.70	0.93	1.46	1.63	1.62	1.23
	Minimum	-0.76	-1.07	-0.54	-0.51	-0.48	-0.55	-0.45
Plot 20	Mean	-0.26	-0.47	0.15	0.38	0.19	-0.08	-0.32
	Std Dev	-5.58	-5.01	-5.34	-5.45	-5.41	-5.52	-5.51
	Maximum	0.75	1.68	1.60	1.68	1.49	1.02	0.71
	Minimum	-1.39	-2.91	-1.23	-0.79	-1.00	-1.12	-1.39
Plot 21	Mean	-0.21	-0.30	-0.40	-0.46	-0.47	-0.48	-0.53
	Std Dev	-5.64	-5.72	-5.76	-5.80	-5.81	-5.75	-5.76
	Maximum	0.64	0.30	0.10	-0.04	-0.06	0.06	-0.02
	Minimum	-1.05	-0.96	-0.94	-0.94	-0.87	-1.07	-1.00
Plot 22	Mean	-0.27	-0.32	-0.34	-0.47	-0.52	-0.52	-0.54
	Std Dev	-5.64	-5.64	-5.59	-5.78	-5.79	-5.70	-5.75
	Maximum	0.59	0.49	0.65	0.03	-0.08	0.09	-0.02
	Minimum	-1.07	-1.18	-1.36	-0.99	-0.99	-1.17	-1.06
Plot 23	Mean	-0.21	-0.28	-0.44	-0.51	-0.55	-0.42	-0.13
	Std Dev	-5.72	-5.75	-5.78	-5.80	-5.74	-5.59	-5.59
	Maximum	0.41	0.26	0.02	-0.11	0.00	0.49	0.77
	Minimum	-0.82	-0.83	-0.94	-0.98	-1.13	-1.30	-1.05
Plot 24	Mean	-0.18	-0.27	-0.46	-0.54	-0.61	-0.55	-0.38
	Std Dev	-5.75	-5.76	-5.79	-5.78	-5.71	-5.61	-5.68
	Maximum	0.43	0.21	-0.04	-0.09	0.00	0.32	0.33
	Minimum	-0.67	-0.78	-0.89	-1.05	-1.26	-1.41	-1.08
Plot 25	Mean	-0.15	-0.29	-0.46	-0.55	-0.65	-0.56	-0.20
	Std Dev	-5.79	-5.75	-5.79	-5.75	-5.63	-5.49	-5.45
	Maximum	0.35	0.23	-0.02	-0.04	0.14	0.57	1.05
	Minimum	-0.57	-0.81	-0.89	-1.11	-1.49	-1.74	-1.45
Plot 26	Mean	-0.14	-0.31	-0.45	-0.55	-0.69	-0.57	0.31
	Std Dev	-5.80	-5.74	-5.80	-5.76	-5.63	-5.09	-4.76
	Maximum	0.39	0.25	-0.02	-0.06	0.17	1.48	2.23
	Minimum	-0.51	-0.84	-0.86	-1.11	-1.51	-2.45	-2.22
Plot 27	Mean	-0.14	-0.30	-0.45	-0.56	-0.72	-0.81	-0.17
	Std Dev	-5.79	-5.74	-5.80	-5.75	-5.62	-5.19	-4.92
	Maximum	0.39	0.26	0.01	-0.03	0.15	0.94	2.08
	Minimum	-0.55	-0.83	-0.87	-1.14	-1.57	-2.43	-2.46

Plot 28	Mean	-0.11	-0.10	-0.11	-0.10	-0.09	-0.09	-0.09
	Std Dev	-5.88	-5.85	-5.86	-5.86	-5.88	-5.86	-5.86
	Maximum	0.19	0.24	0.26	0.23	0.18	0.32	0.23
	Minimum	-0.38	-0.43	-0.42	-0.40	-0.36	-0.36	-0.44
Plot 29	Mean	-0.28	0.56	0.51	-0.09	-0.85	-0.76	-0.63
	Std Dev	-5.32	-5.25	-5.22	-5.03	-5.42	-5.53	-5.71
	Maximum	1.44	1.96	2.17	2.01	0.40	0.20	0.00
	Minimum	-1.82	-1.11	-1.16	-2.01	-2.09	-1.95	-1.24
Plot 30	Mean	-0.28	0.58	0.51	-0.02	-0.86	-0.77	-0.64
	Std Dev	-5.40	-5.26	-5.28	-4.99	-5.34	-5.51	-5.70
	Maximum	1.22	1.94	2.02	2.09	0.60	0.27	0.00
	Minimum	-1.68	-0.94	-1.02	-2.09	-2.26	-1.99	-1.24
Plot 31	Mean	-0.33	0.52	0.38	0.03	-0.73	-0.76	-0.65
	Std Dev	-5.53	-5.25	-5.37	-5.28	-5.17	-5.50	-5.69
	Maximum	0.93	2.13	1.77	1.50	1.11	0.29	0.02
	Minimum	-1.46	-1.21	-0.88	-1.85	-2.50	-1.94	-1.27
Plot 32	Mean	-0.32	0.51	0.41	0.10	-0.66	-0.78	-0.66
	Std Dev	-5.52	-5.28	-5.38	-5.31	-5.14	-5.46	-5.69
	Maximum	0.93	2.10	1.77	1.61	1.21	0.42	0.01
	Minimum	-1.46	-1.09	-0.87	-1.53	-2.42	-2.21	-1.26
Plot 33	Mean	-0.36	0.25	0.15	-0.10	-0.52	-0.73	-0.69
	Std Dev	-5.68	-5.39	-5.52	-5.62	-5.35	-5.49	-5.67
	Maximum	0.42	1.56	1.22	0.83	0.85	0.37	0.04
	Minimum	-1.10	-1.15	-0.82	-0.95	-1.85	-1.89	-1.32
Plot 34	Mean	-0.33	0.25	0.22	0.04	-0.43	-0.73	-0.69
	Std Dev	-5.65	-5.42	-5.49	-5.52	-5.27	-5.42	-5.65
	Maximum	0.61	1.53	1.33	1.19	1.13	0.67	0.07
	Minimum	-1.18	-1.09	-0.87	-1.03	-1.87	-2.14	-1.36
Plot 35	Mean	-0.32	-0.45	-0.52	-0.52	-0.55	-0.60	-0.56
	Std Dev	-5.72	-5.66	-5.74	-5.78	-5.71	-5.61	-5.71
	Maximum	0.38	0.28	0.06	-0.04	0.07	0.23	0.06
	Minimum	-1.00	-1.28	-1.12	-1.00	-1.15	-1.55	-1.15
Plot 36	Mean	-0.30	-0.46	-0.51	-0.52	-0.55	-0.56	-0.52
	Std Dev	-5.73	-5.67	-5.74	-5.78	-5.77	-5.68	-5.75
	Maximum	0.28	0.23	0.04	-0.08	-0.02	0.15	0.02
	Minimum	-0.87	-1.20	-1.08	-0.98	-1.05	-1.29	-1.01
Plot 37	Mean	-0.28	-0.48	-0.53	-0.52	-0.57	-0.54	-0.50
	Std Dev	-5.69	-5.65	-5.72	-5.78	-5.76	-5.70	-5.75
	Maximum	0.38	0.31	0.03	-0.06	-0.09	0.13	0.05
	Minimum	-1.05	-1.28	-1.19	-1.01	-1.08	-1.25	-1.02
Plot 38	Mean	-0.22	-0.45	-0.51	-0.51	-0.53	-0.49	-0.49
	Std Dev	-5.69	-5.66	-5.72	-5.79	-5.78	-5.74	-5.75
	Maximum	0.51	0.30	0.04	-0.09	-0.04	0.09	0.03
	Minimum	-0.96	-1.24	-1.16	-0.99	-0.95	-1.10	-1.02
Plot 39	Mean	-0.22	-0.45	-0.51	-0.52	-0.55	-0.50	-0.48
	Std Dev	-5.65	-5.64	-5.72	-5.78	-5.76	-5.74	-5.76
	Maximum	0.59	0.31	0.03	-0.08	-0.05	0.08	0.04
	Minimum	-0.94	-1.25	-1.16	-0.99	-1.03	-1.08	-0.98
Plot 40	Mean	-0.18	-0.40	-0.48	-0.49	-0.49	-0.47	-0.49
	Std Dev	-5.67	-5.68	-5.74	-5.79	-5.80	-5.75	-5.75
	Maximum	0.61	0.26	0.04	-0.08	-0.06	0.06	0.03
	Minimum	-0.91	-1.11	-1.10	-0.95	-0.89	-1.04	-1.01
Plot 41	Mean	-0.18	-0.41	-0.48	-0.49	-0.48	-0.46	-0.49
	Std Dev	-5.65	-5.67	-5.73	-5.79	-5.79	-5.75	-5.76
	Maximum	0.65	0.33	0.08	-0.07	-0.05	0.07	0.03

	Minimum	-0.92	-1.16	-1.12	-0.94	-0.89	-0.98	-0.99
Plot 42	Mean	-0.14	-0.35	-0.45	-0.46	-0.44	-0.45	-0.51
	Std Dev	-5.64	-5.70	-5.76	-5.80	-5.81	-5.76	-5.76
	Maximum	0.74	0.29	0.06	-0.05	-0.04	0.10	0.01
	Minimum	-0.94	-1.02	-1.01	-0.92	-0.85	-0.95	-0.98
Plot 43	Mean	-0.11	-0.31	-0.42	-0.46	-0.45	-0.46	-0.53
	Std Dev	-5.63	-5.74	-5.78	-5.81	-5.80	-5.74	-5.75
	Maximum	0.73	0.24	0.04	-0.05	-0.03	0.11	-0.04
	Minimum	-0.90	-0.91	-0.89	-0.90	-0.89	-1.00	-1.02
Plot 44	Mean	-0.09	-0.31	-0.42	-0.49	-0.51	-0.50	-0.55
	Std Dev	-5.65	-5.74	-5.78	-5.80	-5.78	-5.70	-5.74
	Maximum	0.76	0.22	0.08	-0.08	-0.06	0.06	-0.05
	Minimum	-0.87	-0.89	-0.88	-0.94	-0.98	-1.13	-1.07
Plot 45	Mean	-0.11	-0.32	-0.45	-0.52	-0.56	-0.53	-0.54
	Std Dev	-5.69	-5.73	-5.78	-5.79	-5.75	-5.65	-5.74
	Maximum	0.58	0.24	0.00	-0.09	-0.02	0.17	-0.01
	Minimum	-0.81	-0.85	-0.92	-1.01	-1.10	-1.27	-1.07
Plot 46	Mean	-0.15	-0.29	-0.44	-0.54	-0.64	-0.77	-0.20
	Std Dev	-5.79	-5.75	-5.80	-5.77	-5.68	-5.36	-4.96
	Maximum	0.35	0.28	0.03	-0.08	0.06	0.62	1.93
	Minimum	-0.60	-0.81	-0.85	-1.05	-1.39	-2.28	-2.35
Plot 47	Mean	-0.15	-0.25	-0.28	-0.19	0.00	0.28	0.65
	Std Dev	-5.79	-5.78	-5.77	-5.69	-5.55	-5.38	-5.21
	Maximum	0.33	0.25	0.25	0.54	0.94	1.61	2.10
	Minimum	-0.58	-0.73	-0.80	-0.89	-1.06	-0.96	-0.86
Plot 48	Mean	-0.14	-0.18	-0.12	0.05	0.28	0.52	0.74
	Std Dev	-5.79	-5.79	-5.73	-5.64	-5.51	-5.36	-5.30
	Maximum	0.32	0.27	0.54	0.92	1.26	1.95	2.05
	Minimum	-0.60	-0.67	-0.66	-0.74	-0.74	-0.76	-0.55
Plot 49	Mean	-0.14	-0.17	-0.08	0.10	0.35	0.56	0.71
	Std Dev	-5.79	-5.79	-5.71	-5.62	-5.50	-5.36	-5.37
	Maximum	0.33	0.29	0.59	0.99	1.38	2.00	2.23
	Minimum	-0.61	-0.66	-0.64	-0.71	-0.69	-0.76	-0.53
Plot 50	Mean	-0.15	-0.15	-0.02	0.19	0.44	0.61	0.71
	Std Dev	-5.78	-5.78	-5.69	-5.59	-5.47	-5.34	-5.39
	Maximum	0.34	0.31	0.70	1.08	1.60	2.05	2.20
	Minimum	-0.64	-0.66	-0.62	-0.69	-0.59	-0.79	-0.47
Plot 51	Mean	-0.15	-0.11	0.04	0.25	0.47	0.62	0.67
	Std Dev	-5.77	-5.76	-5.67	-5.58	-5.46	-5.34	-5.43
	Maximum	0.32	0.42	0.79	1.16	1.70	2.04	2.07
	Minimum	-0.66	-0.68	-0.56	-0.64	-0.60	-0.69	-0.45
Plot 52	Mean	-0.17	-0.12	0.06	0.31	0.54	0.63	0.63
	Std Dev	-5.77	-5.78	-5.67	-5.57	-5.45	-5.35	-5.48
	Maximum	0.31	0.34	0.78	1.21	1.68	1.98	1.77
	Minimum	-0.64	-0.61	-0.56	-0.62	-0.48	-0.57	-0.37
Plot 53	Mean	-0.18	-0.16	0.03	0.29	0.53	0.62	0.61
	Std Dev	-5.76	-5.76	-5.66	-5.56	-5.45	-5.34	-5.47
	Maximum	0.32	0.38	0.82	1.18	1.75	2.01	1.75
	Minimum	-0.68	-0.74	-0.63	-0.63	-0.55	-0.57	-0.43
Plot 54	Mean	-0.18	-0.15	0.06	0.34	0.56	0.62	0.60
	Std Dev	-5.76	-5.74	-5.64	-5.54	-5.43	-5.33	-5.48
	Maximum	0.31	0.44	0.86	1.32	1.71	2.09	1.77
	Minimum	-0.67	-0.78	-0.65	-0.66	-0.46	-0.55	-0.42
Plot 55	Mean	-0.20	-0.21	0.01	0.32	0.57	0.60	0.52
	Std Dev	-5.75	-5.73	-5.62	-5.51	-5.42	-5.33	-5.50

Plot 55	Maximum	0.34	0.44	0.86	1.37	1.86	2.09	1.57
	Minimum	-0.72	-0.92	-0.73	-0.74	-0.47	-0.54	-0.45
Plot 56	Mean	-0.18	-0.04	0.23	0.47	0.61	0.59	0.50
	Std Dev	-5.73	-5.59	-5.61	-5.49	-5.40	-5.33	-5.51
	Maximum	0.40	0.93	1.17	1.62	1.81	2.08	1.53
	Minimum	-0.80	-1.02	-0.54	-0.54	-0.54	-0.57	-0.46
Plot 57	Mean	-0.19	-0.08	0.25	0.50	0.62	0.58	0.54
	Std Dev	-5.71	-5.53	-5.59	-5.47	-5.40	-5.35	-5.52
	Maximum	0.42	1.04	1.24	1.68	1.92	2.02	1.59
	Minimum	-0.86	-1.22	-0.52	-0.59	-0.48	-0.54	-0.34
Plot 58	Mean	-0.22	-0.23	0.15	0.45	0.60	0.54	0.47
	Std Dev	-5.73	-5.57	-5.62	-5.48	-5.40	-5.37	-5.54
	Maximum	0.37	0.83	1.01	1.63	1.80	1.92	1.48
	Minimum	-0.77	-1.29	-0.63	-0.55	-0.52	-0.58	-0.34
Plot 59	Mean	-0.30	-0.72	0.20	0.56	0.35	0.02	-0.29
	Std Dev	-5.49	-4.92	-5.10	-5.35	-5.29	-5.45	-5.53
	Maximum	1.11	1.51	2.19	1.89	1.77	1.25	0.69
	Minimum	-1.63	-2.69	-1.64	-0.63	-1.13	-1.10	-1.29
Plot 60	Mean							
	Std Dev							
	Maximum							
	Minimum							
Plot 61	Mean							
	Std Dev							
	Maximum							
	Minimum							
Plot 62	Mean							
	Std Dev							
	Maximum							
	Minimum							
Plot 63	Mean							
	Std Dev							
	Maximum							
	Minimum							
Plot 64	Mean							
	Std Dev							
	Maximum							
	Minimum							

157.5	180	202.5	225	247.5	270	292.5	315	337.5
-0.39	-0.18	0.01	0.13	0.25	0.31	0.34	0.52	0.38
-5.81	-5.77	-5.72	-5.70	-5.56	-5.50	-5.49	-5.42	-5.52
-0.01	0.29	0.58	0.72	1.26	1.39	1.50	1.76	1.52
-0.80	-0.69	-0.55	-0.51	-0.67	-0.73	-0.68	-0.67	-0.58
-0.43	-0.22	-0.02	0.12	0.19	0.15	-0.03	-0.01	-0.09
-5.80	-5.75	-5.71	-5.72	-5.61	-5.54	-5.66	-5.65	-5.64
-0.02	0.30	0.54	0.69	1.03	1.15	0.71	0.81	0.77
-0.82	-0.78	-0.66	-0.45	-0.63	-0.81	-0.81	-0.77	-0.88
-0.09	0.24	0.04	0.31	-0.23	-0.61	-0.63	-0.62	-0.50
-5.67	-5.48	-5.64	-5.38	-5.24	-5.43	-5.53	-5.47	-5.59
0.71	1.39	0.86	1.70	1.63	0.64	0.40	0.61	0.42
-0.82	-0.84	-0.75	-0.97	-1.68	-1.65	-1.66	-1.75	-1.45
-0.06	0.29	0.08	0.35	0.06	-0.22	-0.41	-0.55	-0.43
-5.63	-5.54	-5.65	-5.51	-5.52	-5.56	-5.60	-5.56	-5.66
0.87	1.32	0.85	1.50	1.22	0.85	0.48	0.41	0.36
-0.86	-0.70	-0.67	-0.55	-0.89	-1.17	-1.36	-1.55	-1.16
0.13	0.44	0.08	0.11	-0.26	-0.51	-0.67	-0.61	-0.37
-5.49	-5.52	-5.60	-5.58	-5.62	-5.62	-5.59	-5.64	-5.74
1.28	1.54	1.16	1.14	0.58	0.33	0.24	0.17	0.17
-0.91	-0.60	-0.72	-0.74	-1.05	-1.36	-1.59	-1.45	-0.90
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
0.30	0.44	0.05	0.04	-0.35	-0.47	-0.53	-0.48	-0.31
-5.43	-5.51	-5.54	-5.56	-5.64	-5.65	-5.67	-5.72	-5.79
1.65	1.57	1.26	1.05	0.40	0.29	0.19	0.16	0.12
-0.88	-0.51	-0.89	-0.87	-1.13	-1.27	-1.30	-1.12	-0.72
0.29	-0.30	-0.45	-0.44	-0.48	-0.49	-0.53	-0.44	-0.31
-5.45	-5.29	-5.45	-5.74	-5.77	-5.75	-5.74	-5.78	-5.79
1.53	1.28	0.73	0.09	-0.04	0.04	0.00	0.06	0.14
-1.02	-1.78	-1.84	-1.02	-0.96	-1.05	-1.04	-0.90	-0.71
0.34	-0.20	-0.40	-0.45	-0.48	-0.50	-0.54	-0.44	-0.31
-5.54	-5.30	-5.47	-5.74	-5.77	-5.76	-5.75	-5.79	-5.80
1.39	1.31	0.64	0.09	-0.04	0.03	-0.08	0.04	0.13
-0.59	-1.67	-1.64	-1.01	-0.95	-1.04	-1.04	-0.89	-0.73
0.32	-0.14	-0.37	-0.45	-0.49	-0.51	-0.55	-0.44	-0.33
-5.60	-5.29	-5.45	-5.74	-5.77	-5.76	-5.74	-5.79	-5.80
1.24	1.48	0.72	0.11	-0.06	0.01	-0.06	0.05	0.09
-0.47	-1.68	-1.75	-1.01	-0.99	-1.03	-1.07	-0.86	-0.74
0.34	-0.04	-0.28	-0.46	-0.49	-0.52	-0.54	-0.44	-0.32
-5.61	-5.44	-5.56	-5.74	-5.77	-5.76	-5.75	-5.79	-5.80
1.23	1.19	0.63	0.04	-0.06	0.02	-0.08	0.04	0.09
-0.42	-1.30	-1.39	-0.99	-0.96	-1.02	-1.03	-0.86	-0.74
0.30	0.01	-0.23	-0.47	-0.50	-0.53	-0.54	-0.45	-0.33
-5.65	-5.57	-5.64	-5.73	-5.77	-5.76	-5.74	-5.79	-5.80
1.07	0.96	0.49	0.05	-0.07	0.03	-0.05	0.04	0.08
-0.40	-0.89	-1.05	-1.03	-1.00	-1.05	-1.04	-0.84	-0.76
0.35	0.17	-0.14	-0.46	-0.49	-0.49	-0.48	-0.44	-0.35
-5.65	-5.63	-5.73	-5.74	-5.78	-5.78	-5.78	-5.79	-5.79
1.10	0.95	0.49	0.05	-0.08	0.01	-0.09	0.05	0.08
-0.33	-0.60	-0.70	-1.00	-0.97	-0.94	-0.89	-0.84	-0.83
0.21	-0.07	-0.17	-0.47	-0.51	-0.50	-0.50	-0.45	-0.36

-5.61	-5.72	-5.73	-5.74	-5.77	-5.77	-5.77	-5.80	-5.80
0.99	0.56	0.43	0.13	-0.08	0.01	-0.07	0.02	0.08
-0.56	-0.65	-0.73	-1.04	-1.00	-0.98	-0.94	-0.85	-0.84
0.23	-0.03	-0.14	-0.46	-0.50	-0.48	-0.49	-0.45	-0.36
-5.62	-5.74	-5.74	-5.74	-5.77	-5.77	-5.77	-5.80	-5.80
1.05	0.52	0.45	0.09	-0.07	0.01	-0.06	0.04	0.07
-0.49	-0.58	-0.65	-1.01	-0.98	-0.94	-0.91	-0.84	-0.82
0.17	-0.04	-0.13	-0.46	-0.50	-0.47	-0.49	-0.45	-0.37
-5.66	-5.77	-5.75	-5.73	-5.76	-5.76	-5.77	-5.80	-5.79
0.90	0.43	0.45	0.10	-0.03	0.04	-0.06	0.05	0.10
-0.52	-0.51	-0.60	-1.03	-1.00	-0.93	-0.92	-0.88	-0.89
0.15	-0.05	-0.12	-0.43	-0.48	-0.44	-0.49	-0.45	-0.38
-5.67	-5.78	-5.77	-5.74	-5.76	-5.76	-5.77	-5.80	-5.78
0.88	0.41	0.40	0.11	-0.02	0.05	-0.04	0.04	0.10
-0.56	-0.50	-0.59	-1.00	-1.01	-0.96	-0.89	-0.86	-0.90
0.21	0.03	-0.10	-0.41	-0.47	-0.44	-0.50	-0.44	-0.38
-5.67	-5.76	-5.77	-5.74	-5.76	-5.76	-5.77	-5.80	-5.79
0.93	0.56	0.45	0.12	-0.03	0.06	-0.04	0.01	0.09
-0.50	-0.49	-0.58	-1.02	-1.01	-0.95	-0.96	-0.86	-0.86
0.16	0.04	-0.08	-0.38	-0.45	-0.44	-0.48	-0.42	-0.37
-5.71	-5.79	-5.77	-5.75	-5.76	-5.77	-5.77	-5.81	-5.79
0.78	0.51	0.46	0.13	0.00	0.03	-0.02	0.03	0.12
-0.46	-0.45	-0.54	-0.88	-1.02	-0.97	-0.91	-0.86	-0.86
-0.35	-0.21	-0.09	-0.40	-0.50	-0.51	-0.50	-0.42	-0.39
-5.70	-5.67	-5.76	-5.70	-5.67	-5.69	-5.72	-5.79	-5.76
0.28	0.49	0.48	0.23	0.20	0.10	0.09	0.06	0.17
-1.03	-0.85	-0.59	-1.04	-1.23	-1.17	-1.07	-0.85	-0.92
-0.39	-0.20	0.02	0.13	0.23	0.35	0.40	0.66	0.54
-5.81	-5.76	-5.71	-5.70	-5.49	-5.41	-5.37	-5.28	-5.39
-0.02	0.30	0.61	0.75	1.33	1.60	1.79	2.14	1.96
-0.82	-0.73	-0.60	-0.52	-0.81	-0.91	-0.90	-0.81	-0.75
-0.42	-0.22	-0.01	0.12	0.17	0.13	-0.05	0.05	0.11
-5.79	-5.75	-5.71	-5.72	-5.63	-5.55	-5.59	-5.42	-5.36
0.01	0.29	0.61	0.72	0.97	1.10	0.87	1.20	1.48
-0.87	-0.76	-0.66	-0.46	-0.62	-0.80	-0.92	-1.12	-1.33
0.13	0.37	0.15	0.41	-0.23	-0.73	-0.75	-0.77	-0.54
-5.55	-5.55	-5.53	-5.29	-4.97	-5.19	-5.35	-5.26	-5.51
1.14	1.38	1.13	2.06	1.77	1.08	0.70	0.97	0.52
-0.78	-0.62	-0.93	-1.02	-2.28	-2.40	-2.18	-2.26	-1.64
-0.08	0.33	0.14	0.45	0.03	-0.50	-0.75	-0.75	-0.45
-5.56	-5.46	-5.52	-5.44	-5.20	-5.11	-5.30	-5.45	-5.63
0.92	1.58	1.20	1.69	1.76	1.53	0.68	0.44	0.38
-1.08	-0.91	-0.85	-0.64	-1.52	-2.27	-2.33	-1.95	-1.24
0.30	0.61	0.15	0.24	-0.31	-0.67	-0.76	-0.56	-0.34
-5.32	-5.42	-5.33	-5.40	-5.48	-5.46	-5.51	-5.63	-5.76
1.77	1.94	1.79	1.57	0.80	0.52	0.29	0.22	0.15
-1.18	-0.52	-1.29	-1.03	-1.30	-1.77	-1.91	-1.43	-0.83
0.59	0.57	0.02	-0.26	-0.42	-0.55	-0.61	-0.49	-0.31
-5.38	-5.44	-5.33	-5.65	-5.71	-5.68	-5.68	-5.73	-5.79
1.91	1.88	1.67	0.54	0.17	0.08	0.05	0.10	0.12
-0.77	-0.56	-1.28	-1.01	-0.99	-1.22	-1.32	-1.13	-0.73
0.37	0.53	0.07	0.01	-0.34	-0.56	-0.64	-0.51	-0.31
-5.38	-5.47	-5.45	-5.61	-5.61	-5.65	-5.63	-5.71	-5.79
1.78	1.72	1.47	0.92	0.45	0.17	0.11	0.11	0.10
-0.90	-0.50	-1.06	-0.83	-1.14	-1.32	-1.47	-1.23	-0.77

-0.09	-0.09	-0.09	-0.09	-0.11	-0.10	-0.10	-0.10	-0.10
-5.88	-5.87	-5.87	-5.86	-5.87	-5.86	-5.87	-5.88	-5.86
0.20	0.20	0.21	0.31	0.23	0.26	0.24	0.21	0.17
-0.34	-0.38	-0.33	-0.42	-0.35	-0.44	-0.35	-0.38	-0.42
-0.39	-0.16	-0.23	-0.54	-0.66	-0.67	-0.54	-0.22	-0.33
-5.78	-5.72	-5.68	-5.66	-5.58	-5.51	-5.42	-5.51	-5.66
0.07	0.50	0.50	0.17	0.27	0.35	0.65	0.86	0.45
-0.94	-0.84	-0.92	-1.25	-1.59	-1.79	-1.92	-1.34	-1.01
-0.39	-0.18	-0.24	-0.54	-0.65	-0.68	-0.60	-0.33	-0.38
-5.78	-5.74	-5.71	-5.68	-5.61	-5.57	-5.48	-5.58	-5.72
0.09	0.38	0.41	0.12	0.19	0.26	0.60	0.60	0.24
-0.93	-0.79	-0.88	-1.21	-1.54	-1.63	-1.83	-1.29	-0.94
-0.40	-0.18	-0.24	-0.52	-0.64	-0.70	-0.69	-0.42	-0.42
-5.77	-5.75	-5.70	-5.68	-5.61	-5.56	-5.43	-5.45	-5.62
0.07	0.30	0.40	0.15	0.19	0.37	0.56	0.79	0.48
-0.97	-0.71	-0.95	-1.19	-1.49	-1.66	-1.96	-1.67	-1.34
-0.42	-0.20	-0.26	-0.52	-0.63	-0.70	-0.74	-0.55	-0.48
-5.77	-5.76	-5.71	-5.68	-5.63	-5.57	-5.42	-5.47	-5.62
0.05	0.34	0.34	0.14	0.12	0.31	0.53	0.65	0.33
-0.97	-0.73	-0.94	-1.18	-1.46	-1.65	-1.98	-1.62	-1.40
-0.43	-0.21	-0.28	-0.51	-0.63	-0.72	-0.85	-0.76	-0.62
-5.74	-5.76	-5.71	-5.69	-5.63	-5.57	-5.41	-5.48	-5.51
0.12	0.28	0.30	0.09	0.17	0.28	0.52	0.38	0.45
-1.10	-0.76	-0.92	-1.15	-1.40	-1.71	-2.09	-1.86	-1.69
-0.45	-0.22	-0.27	-0.50	-0.62	-0.71	-0.84	-0.77	-0.64
-5.73	-5.76	-5.71	-5.69	-5.63	-5.59	-5.43	-5.52	-5.53
0.17	0.29	0.33	0.10	0.20	0.27	0.43	0.32	0.34
-1.09	-0.79	-0.93	-1.12	-1.37	-1.63	-2.03	-1.79	-1.71
-0.34	-0.24	-0.15	-0.21	-0.06	0.16	0.40	0.58	0.24
-5.78	-5.73	-5.76	-5.71	-5.56	-5.41	-5.36	-5.34	-5.41
0.17	0.36	0.36	0.44	1.05	1.39	1.90	2.07	1.70
-0.83	-0.87	-0.73	-0.84	-1.00	-1.07	-0.84	-0.71	-0.81
-0.35	-0.21	-0.07	-0.02	0.17	0.36	0.50	0.55	0.33
-5.81	-5.77	-5.79	-5.73	-5.58	-5.45	-5.45	-5.46	-5.54
0.03	0.30	0.38	0.58	1.14	1.44	1.67	1.73	1.22
-0.79	-0.69	-0.51	-0.58	-0.65	-0.76	-0.61	-0.49	-0.53
-0.36	-0.21	-0.07	-0.01	0.22	0.40	0.50	0.52	0.31
-5.80	-5.76	-5.78	-5.70	-5.54	-5.44	-5.43	-5.46	-5.52
0.05	0.30	0.40	0.65	1.21	1.45	1.68	1.68	1.51
-0.78	-0.73	-0.52	-0.63	-0.68	-0.80	-0.65	-0.55	-0.67
-0.43	-0.22	0.02	0.24	0.41	0.48	0.46	0.36	0.24
-5.79	-5.75	-5.68	-5.62	-5.50	-5.44	-5.43	-5.53	-5.56
0.01	0.30	0.71	1.06	1.54	1.65	1.71	1.38	1.21
-0.87	-0.79	-0.66	-0.61	-0.57	-0.67	-0.62	-0.66	-0.68
-0.41	-0.21	-0.03	0.12	0.35	0.46	0.48	0.42	0.28
-5.80	-5.76	-5.74	-5.68	-5.51	-5.44	-5.44	-5.52	-5.54
-0.01	0.29	0.56	0.87	1.47	1.58	1.64	1.45	1.38
-0.85	-0.72	-0.54	-0.59	-0.62	-0.72	-0.60	-0.58	-0.69
-0.42	-0.21	0.03	0.28	0.48	0.51	0.44	0.34	0.23
-5.80	-5.75	-5.66	-5.56	-5.45	-5.42	-5.45	-5.56	-5.60
0.01	0.32	0.80	1.23	1.70	1.69	1.68	1.29	1.10
-0.82	-0.77	-0.70	-0.68	-0.62	-0.75	-0.58	-0.59	-0.62
-0.41	-0.21	-0.04	0.10	0.40	0.50	0.45	0.40	0.28
-5.81	-5.76	-5.73	-5.61	-5.43	-5.40	-5.45	-5.53	-5.57
-0.02	0.30	0.58	1.05	1.77	1.78	1.66	1.39	1.24

-0.80	-0.71	-0.61	-0.76	-0.69	-0.79	-0.58	-0.59	-0.60
-0.41	-0.22	0.03	0.25	0.46	0.53	0.47	0.44	0.35
-5.80	-5.75	-5.66	-5.64	-5.45	-5.39	-5.41	-5.48	-5.53
-0.02	0.29	0.77	1.02	1.78	1.88	1.83	1.62	1.45
-0.83	-0.79	-0.67	-0.53	-0.59	-0.72	-0.63	-0.59	-0.64
-0.41	-0.26	0.05	0.30	0.47	0.52	0.46	0.40	0.33
-5.80	-5.73	-5.61	-5.63	-5.45	-5.39	-5.40	-5.51	-5.56
-0.01	0.24	0.87	1.07	1.72	1.76	1.80	1.51	1.30
-0.85	-0.88	-0.80	-0.48	-0.61	-0.72	-0.76	-0.61	-0.58
-0.43	-0.35	0.02	0.42	0.52	0.49	0.40	0.22	0.19
-5.78	-5.63	-5.41	-5.53	-5.40	-5.41	-5.39	-5.56	-5.62
0.00	0.37	1.22	1.38	1.90	1.71	1.80	1.23	1.01
-0.91	-1.18	-1.21	-0.59	-0.59	-0.67	-0.84	-0.70	-0.64
-0.42	-0.33	-0.02	0.55	0.50	0.32	0.16	-0.07	-0.06
-5.78	-5.62	-5.25	-5.40	-5.31	-5.40	-5.40	-5.59	-5.68
0.05	0.44	1.50	1.76	2.08	1.68	1.50	0.91	0.63
-0.91	-1.21	-1.65	-0.77	-0.75	-0.83	-0.96	-0.93	-0.77
0.46	0.64	0.23	0.08	-0.27	-0.52	-0.62	-0.53	-0.34
-5.34	-5.43	-5.36	-5.59	-5.61	-5.63	-5.65	-5.72	-5.78
1.88	1.87	1.79	1.05	0.64	0.25	0.14	0.06	0.12
-0.90	-0.45	-1.06	-0.80	-1.09	-1.28	-1.37	-1.20	-0.80
0.37	-0.35	-0.43	-0.42	-0.47	-0.49	-0.55	-0.46	-0.33
-5.30	-5.35	-5.52	-5.75	-5.77	-5.74	-5.72	-5.76	-5.79
1.79	1.05	0.63	0.10	0.01	0.04	0.00	0.07	0.13
-1.11	-1.73	-1.49	-0.99	-1.00	-1.03	-1.11	-0.97	-0.79
0.39	-0.28	-0.41	-0.43	-0.47	-0.50	-0.54	-0.44	-0.32
-5.41	-5.34	-5.53	-5.75	-5.77	-5.76	-5.74	-5.78	-5.79
1.60	1.16	0.54	0.08	-0.02	0.01	0.00	0.05	0.11
-0.80	-1.62	-1.44	-0.99	-0.99	-1.02	-1.08	-0.92	-0.80
0.39	-0.17	-0.38	-0.43	-0.48	-0.50	-0.53	-0.43	-0.32
-5.54	-5.32	-5.52	-5.75	-5.77	-5.76	-5.74	-5.79	-5.80
1.41	1.32	0.60	0.09	-0.03	0.03	0.00	0.05	0.12
-0.54	-1.56	-1.51	-0.99	-0.98	-1.02	-1.06	-0.88	-0.78
0.38	-0.11	-0.35	-0.44	-0.48	-0.50	-0.51	-0.42	-0.32
-5.55	-5.40	-5.54	-5.75	-5.77	-5.76	-5.74	-5.79	-5.79
1.38	1.20	0.52	0.07	-0.05	0.03	0.00	0.05	0.10
-0.58	-1.34	-1.40	-0.98	-1.01	-1.00	-1.10	-0.81	-0.75
0.34	-0.05	-0.30	-0.44	-0.48	-0.50	-0.49	-0.42	-0.33
-5.59	-5.47	-5.58	-5.75	-5.77	-5.76	-5.74	-5.79	-5.79
1.25	1.12	0.50	0.06	-0.03	0.04	0.01	0.05	0.08
-0.49	-1.16	-1.22	-0.99	-0.99	-1.00	-1.05	-0.79	-0.80
0.32	0.04	-0.17	-0.45	-0.48	-0.48	-0.46	-0.42	-0.34
-5.63	-5.68	-5.72	-5.75	-5.78	-5.77	-5.78	-5.80	-5.79
1.15	0.71	0.46	0.09	-0.04	0.03	-0.03	0.03	0.09
-0.38	-0.66	-0.74	-1.01	-1.02	-0.93	-0.92	-0.82	-0.81
0.26	-0.05	-0.24	-0.45	-0.49	-0.48	-0.46	-0.41	-0.34
-5.58	-5.67	-5.67	-5.75	-5.77	-5.76	-5.77	-5.79	-5.79
1.20	0.67	0.43	0.06	-0.06	0.00	0.03	0.05	0.10
-0.62	-0.78	-0.97	-1.00	-1.00	-0.96	-0.90	-0.84	-0.84
0.26	-0.03	-0.22	-0.44	-0.48	-0.46	-0.45	-0.42	-0.35
-5.59	-5.68	-5.69	-5.75	-5.77	-5.76	-5.78	-5.80	-5.79
1.16	0.68	0.42	0.06	-0.03	0.03	0.02	0.03	0.10
-0.61	-0.72	-0.89	-0.96	-0.97	-0.99	-0.89	-0.86	-0.82
0.19	-0.04	-0.20	-0.44	-0.48	-0.45	-0.45	-0.42	-0.36
-5.63	-5.75	-5.72	-5.74	-5.77	-5.76	-5.78	-5.80	-5.79

1.01	0.50	0.37	0.07	-0.03	0.06	0.00	0.03	0.09
-0.51	-0.58	-0.79	-1.01	-1.01	-0.96	-0.87	-0.84	-0.87
0.18	-0.04	-0.17	-0.41	-0.46	-0.44	-0.45	-0.42	-0.37
-5.64	-5.77	-5.75	-5.75	-5.77	-5.76	-5.78	-5.80	-5.79
0.97	0.48	0.39	0.12	-0.02	0.09	0.02	0.03	0.10
-0.53	-0.56	-0.69	-0.96	-0.96	-0.94	-0.86	-0.81	-0.87
0.28	0.05	-0.14	-0.40	-0.46	-0.44	-0.46	-0.42	-0.36
-5.62	-5.72	-5.75	-5.75	-5.77	-5.76	-5.78	-5.80	-5.79
1.16	0.61	0.44	0.09	-0.03	0.07	0.02	0.03	0.08
-0.49	-0.56	-0.70	-0.93	-0.93	-1.05	-0.89	-0.81	-0.84
0.23	0.06	-0.11	-0.38	-0.45	-0.44	-0.46	-0.41	-0.37
-5.66	-5.77	-5.76	-5.76	-5.77	-5.77	-5.77	-5.81	-5.79
0.96	0.54	0.42	0.12	-0.03	0.07	0.02	0.03	0.10
-0.48	-0.42	-0.63	-0.90	-1.04	-0.94	-0.91	-0.81	-0.87
-0.36	-0.24	-0.16	-0.41	-0.52	-0.55	-0.50	-0.40	-0.38
-5.71	-5.72	-5.77	-5.72	-5.70	-5.68	-5.68	-5.79	-5.76
0.28	0.32	0.39	0.17	0.11	0.14	0.15	0.09	0.12
-1.00	-0.87	-0.63	-1.00	-1.16	-1.23	-1.19	-0.85	-0.92

Name
DNC01
DNC02
DSC01
DSC02
DSC03
CSC01
CEC01
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CEC04
CEC05
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DSD03
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CSD01

CED01
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ANF03
ANF04
ANF05
ANF06
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BWF01
BWF02
BWF03
BWF04
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CWF02
CWF03
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DNC02

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CEC03

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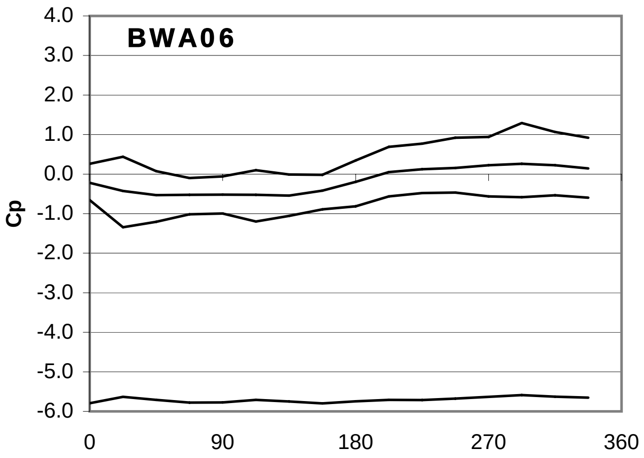
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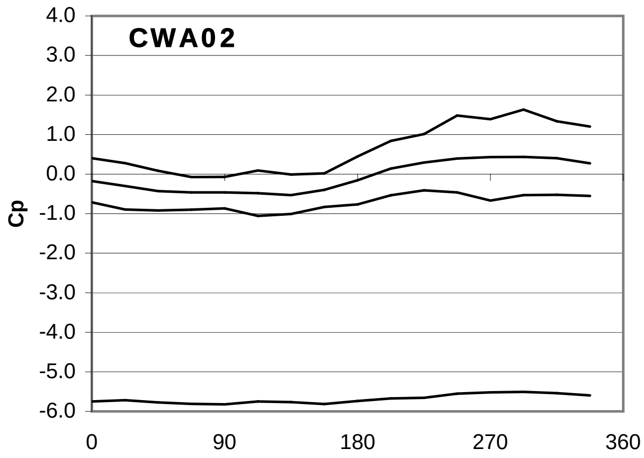
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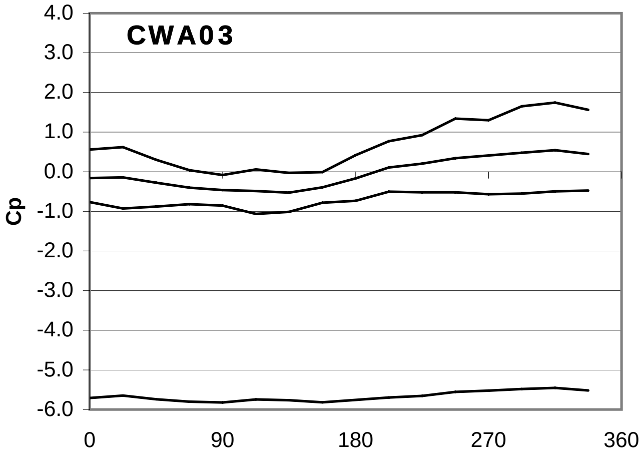
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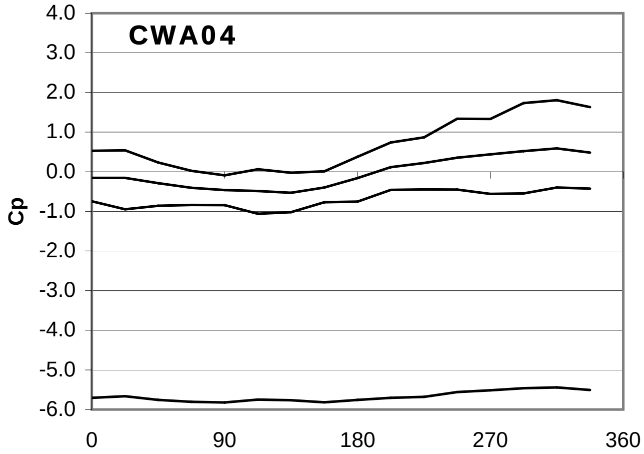
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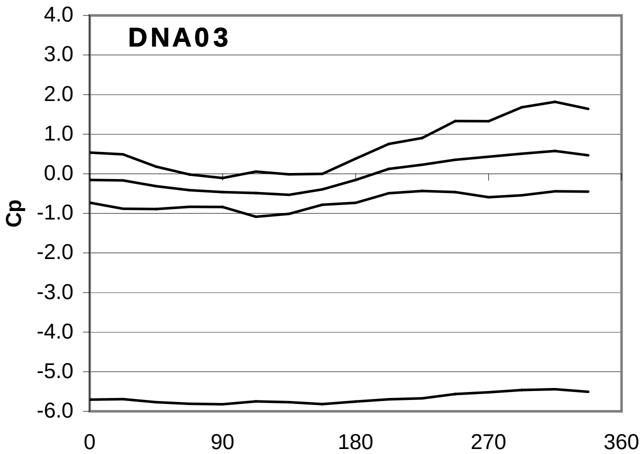
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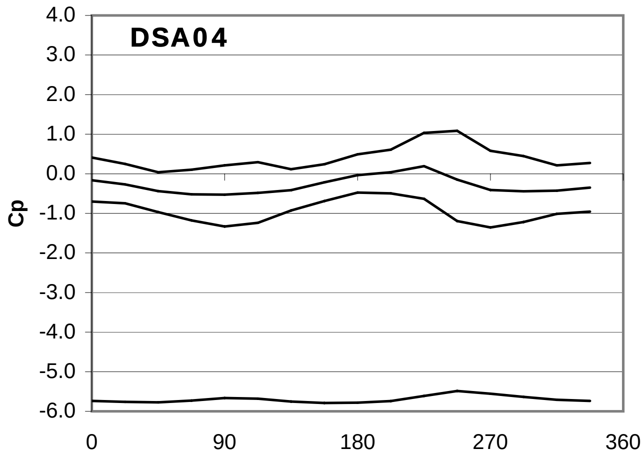
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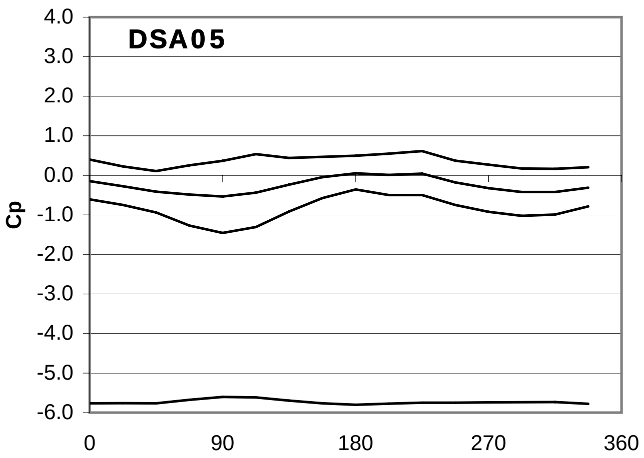
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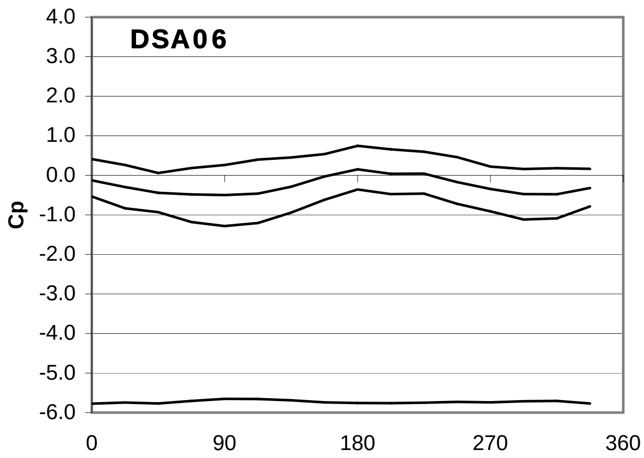
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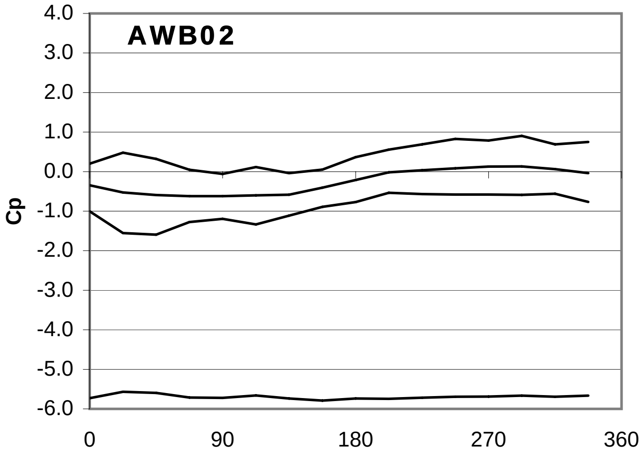
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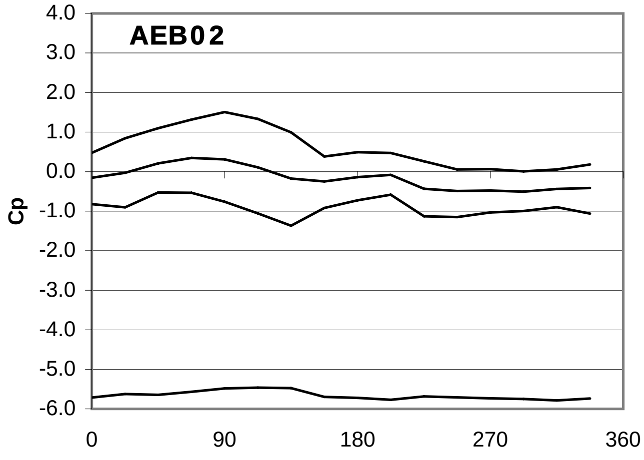
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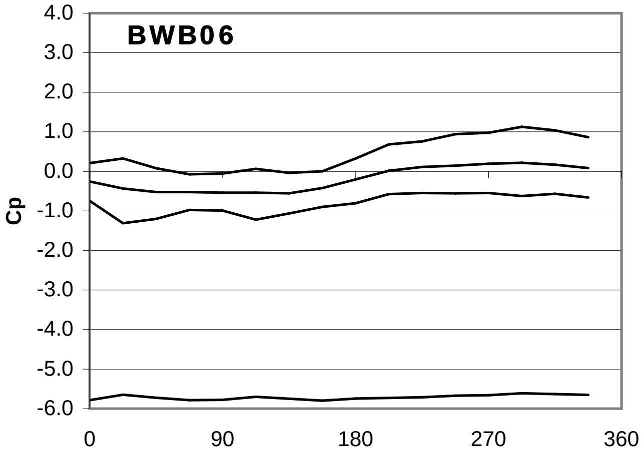
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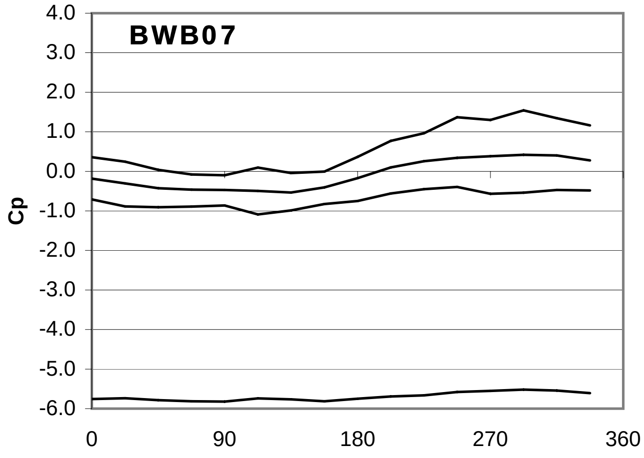
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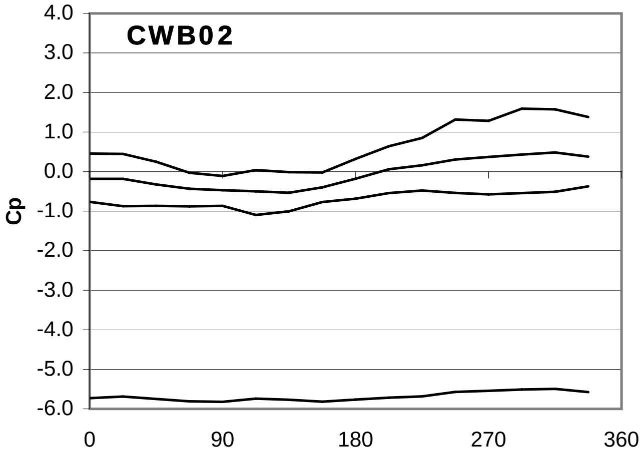
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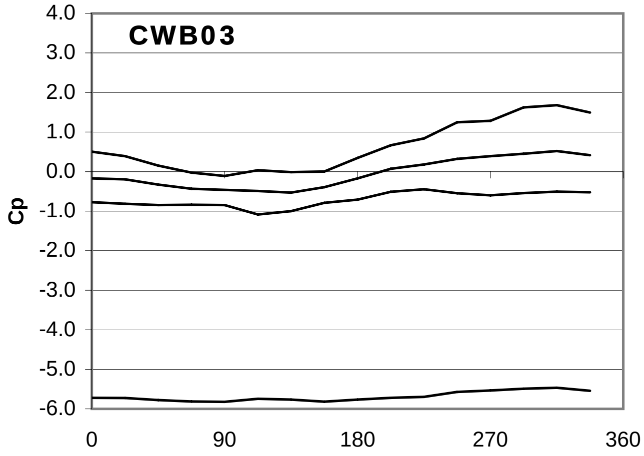
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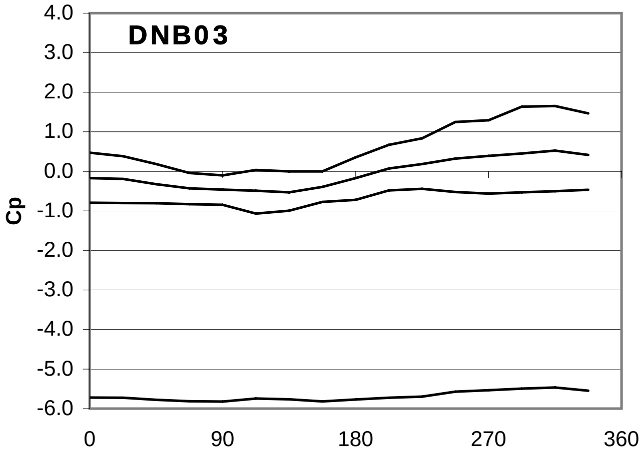
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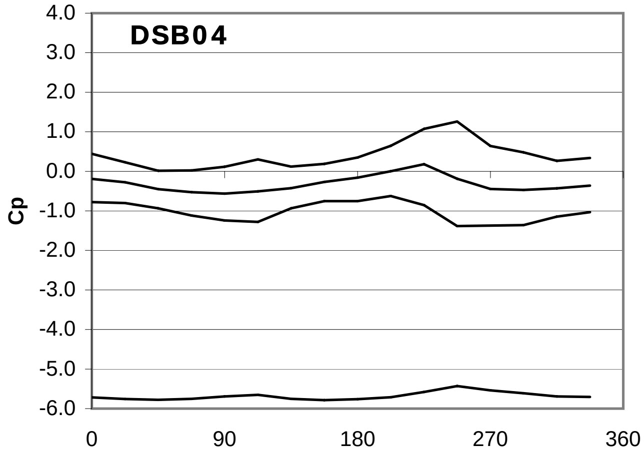
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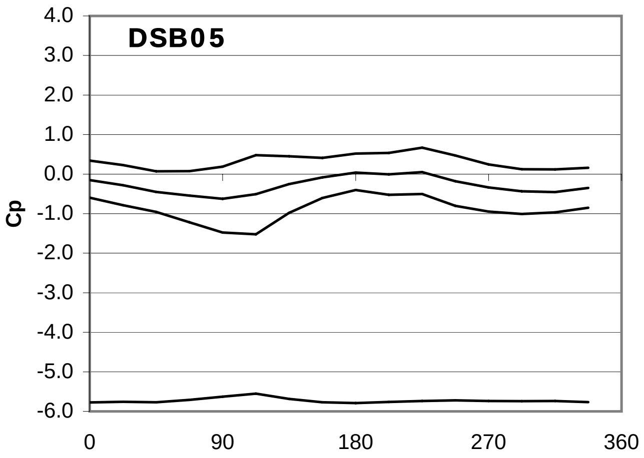
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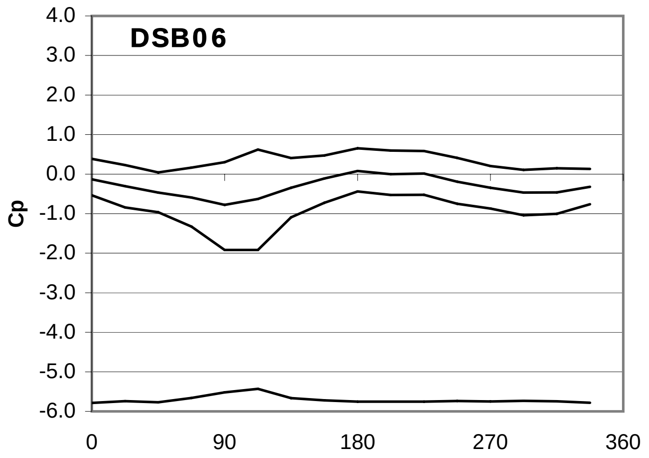
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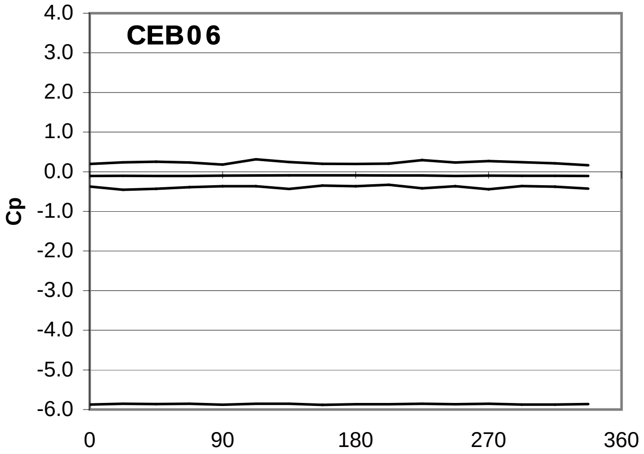
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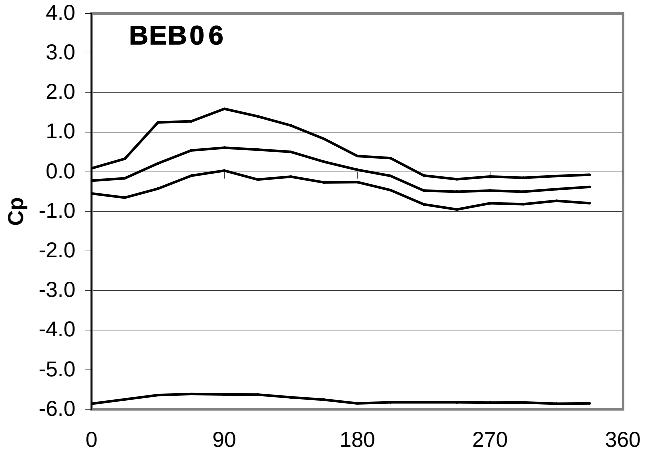
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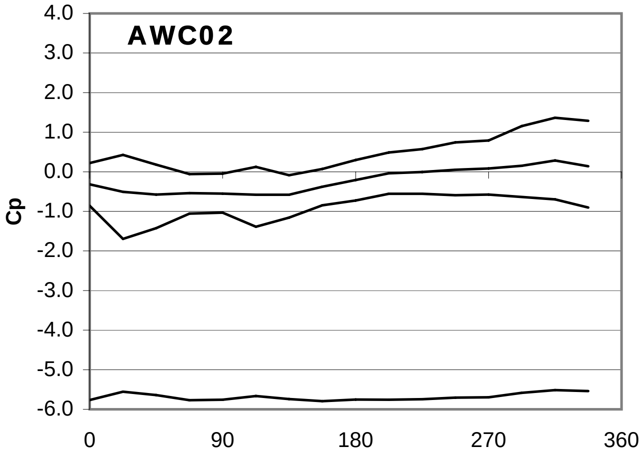
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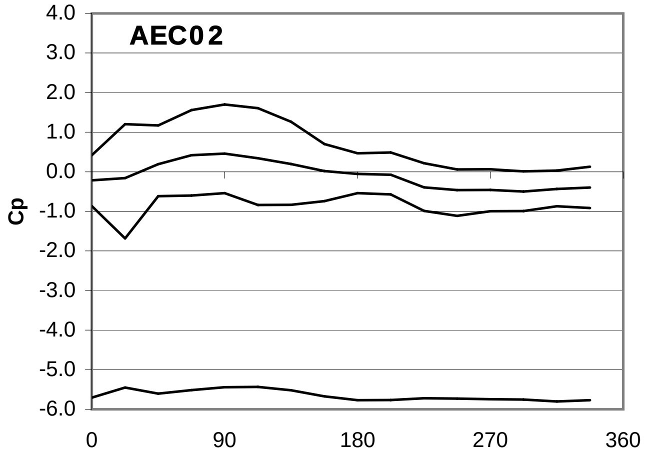
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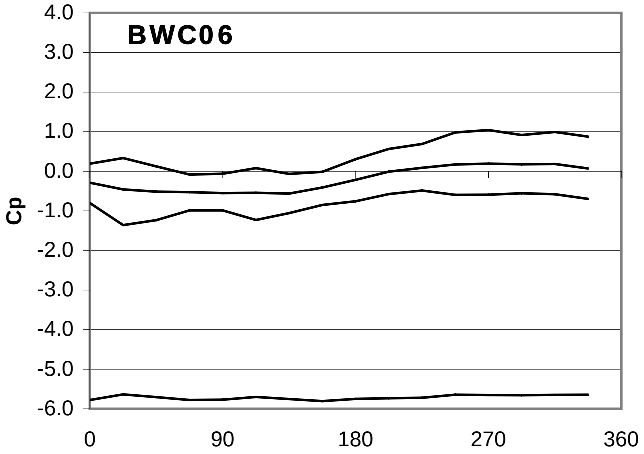
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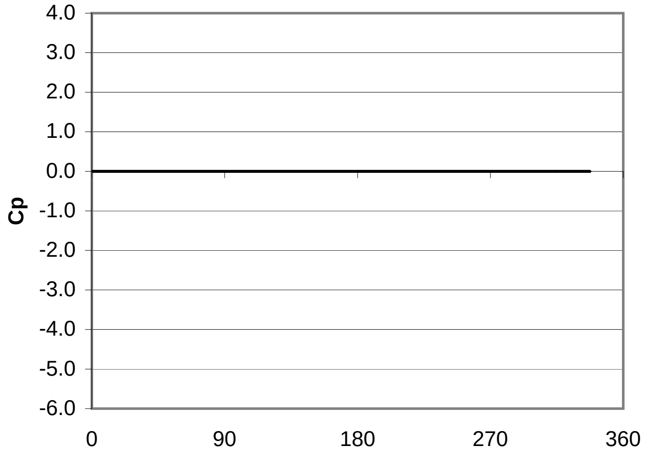
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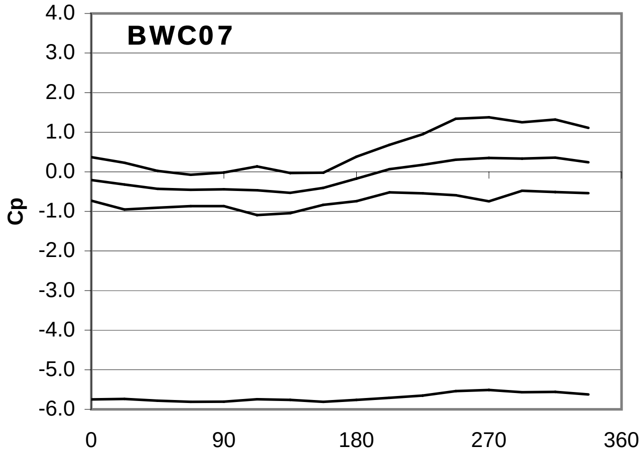
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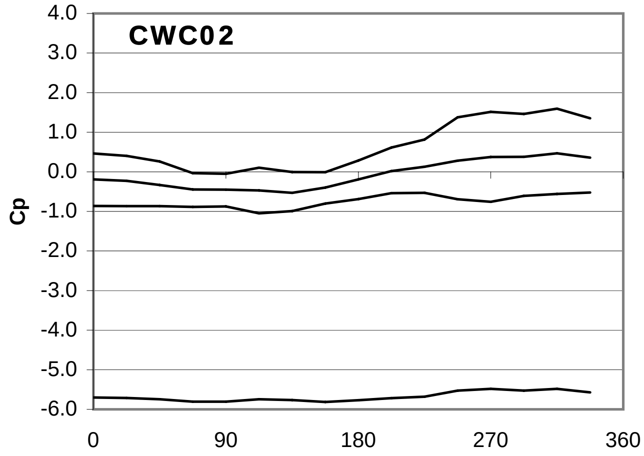
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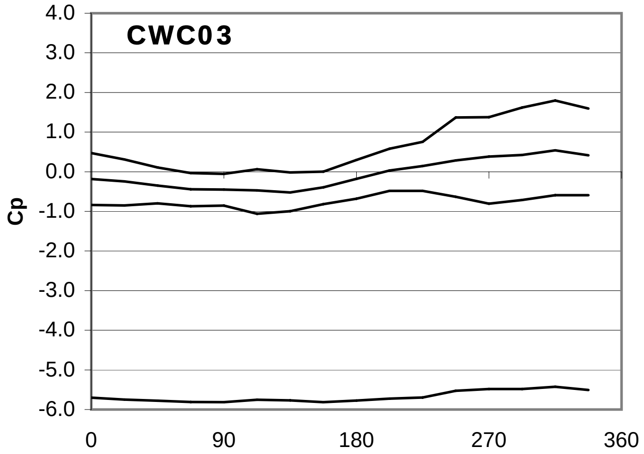
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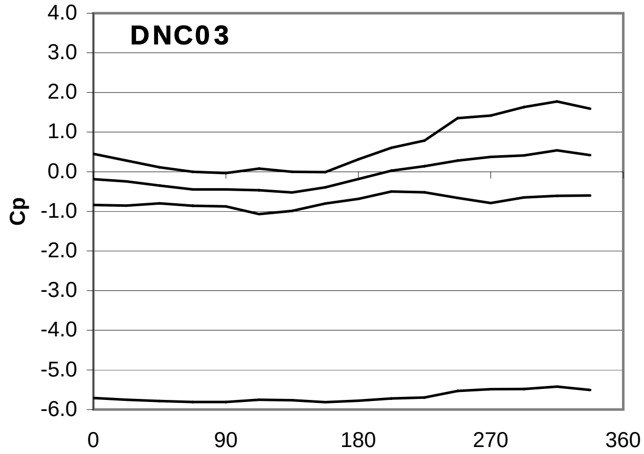
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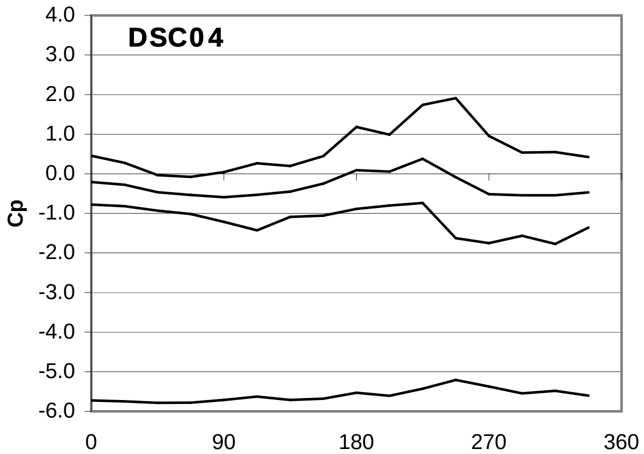
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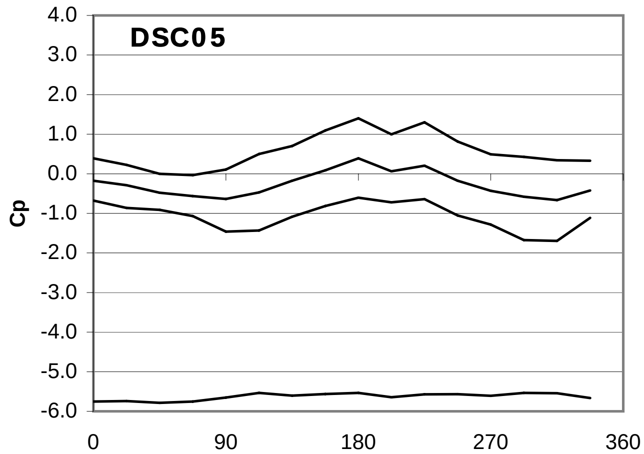
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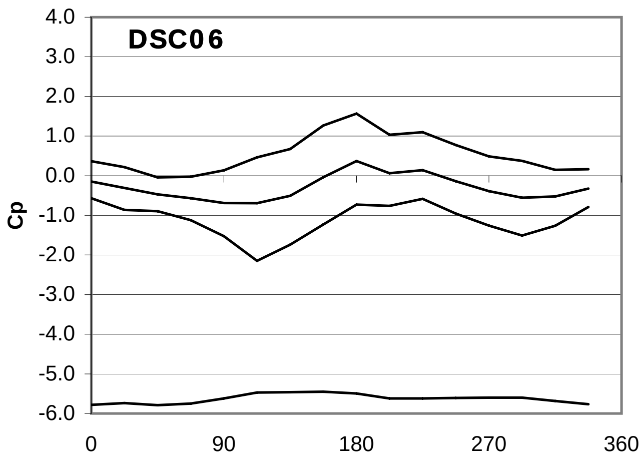
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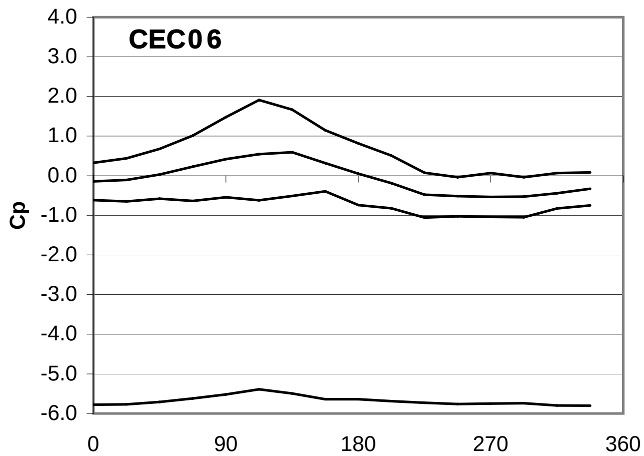
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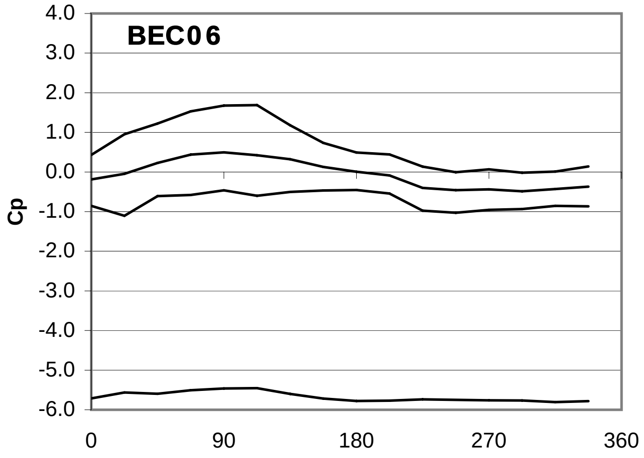
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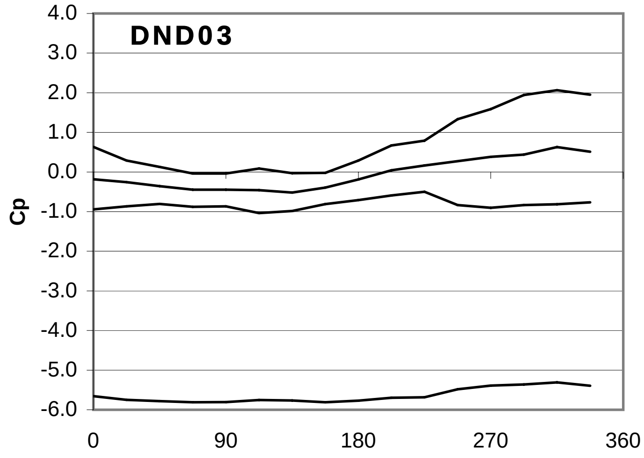
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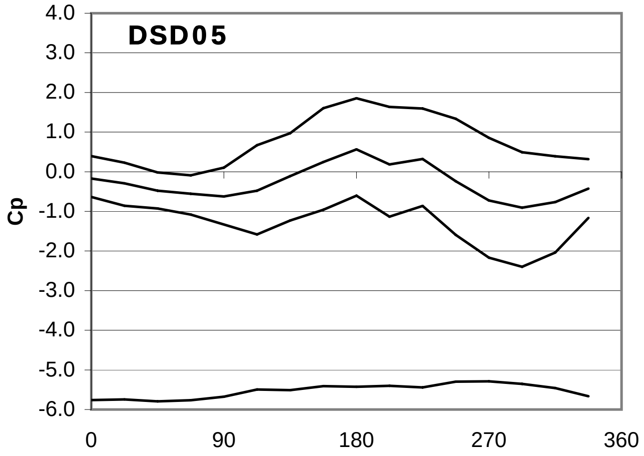
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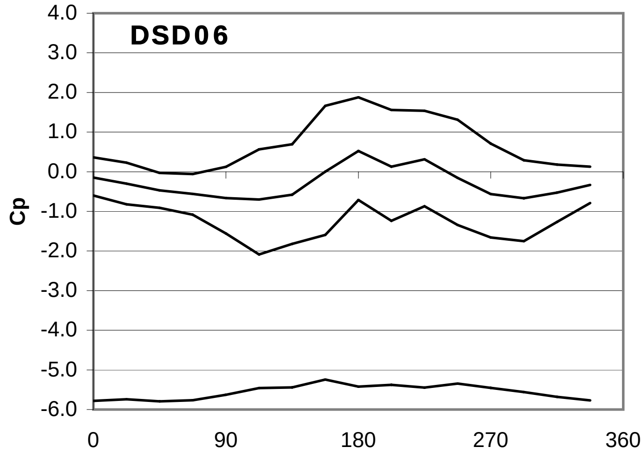
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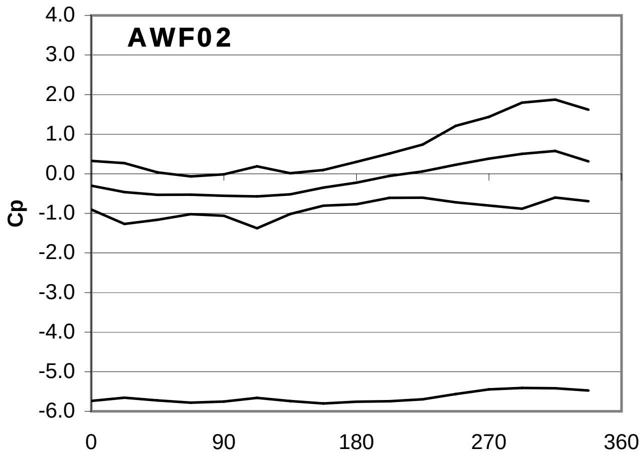
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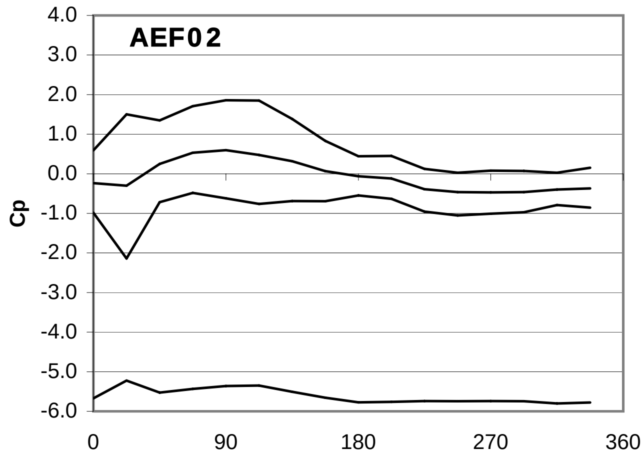
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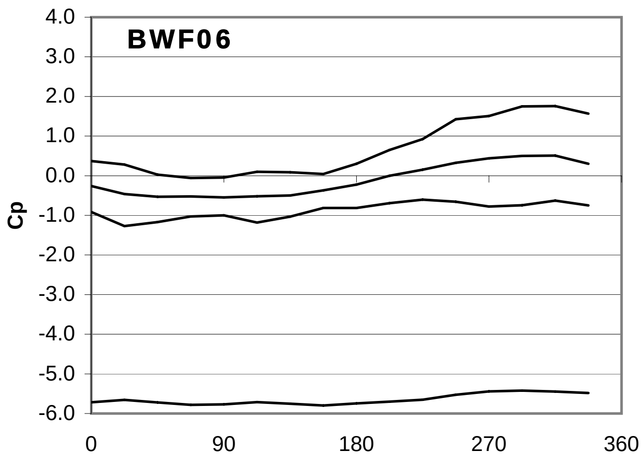
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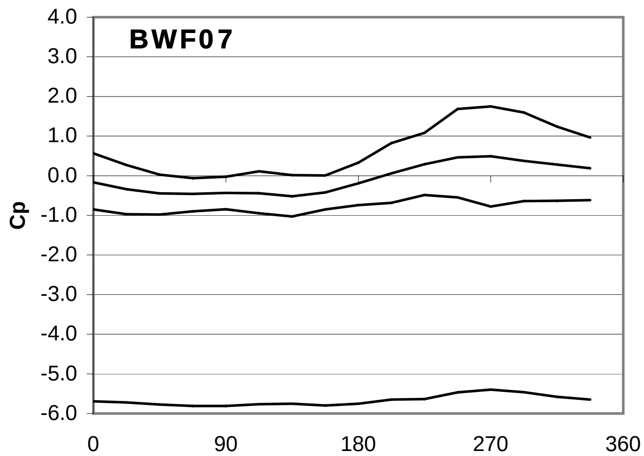
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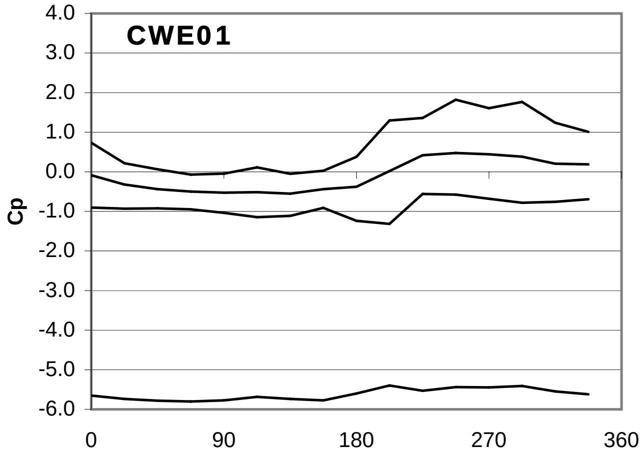
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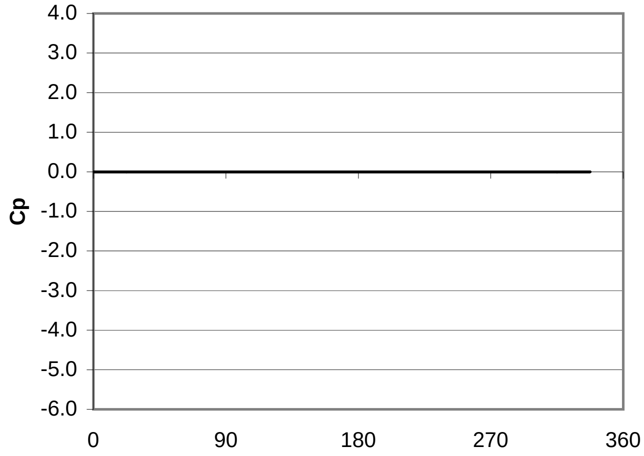
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CWE02
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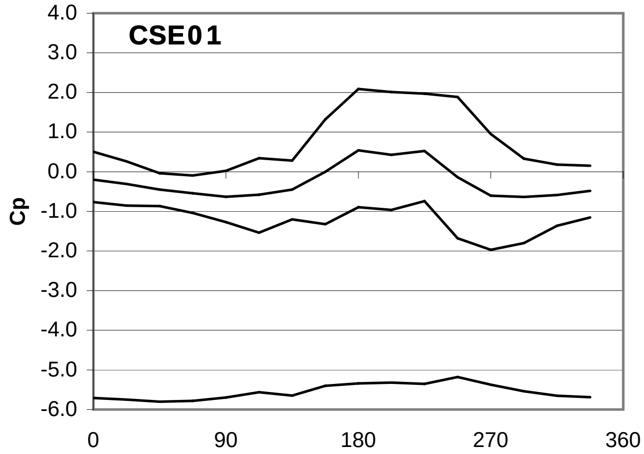
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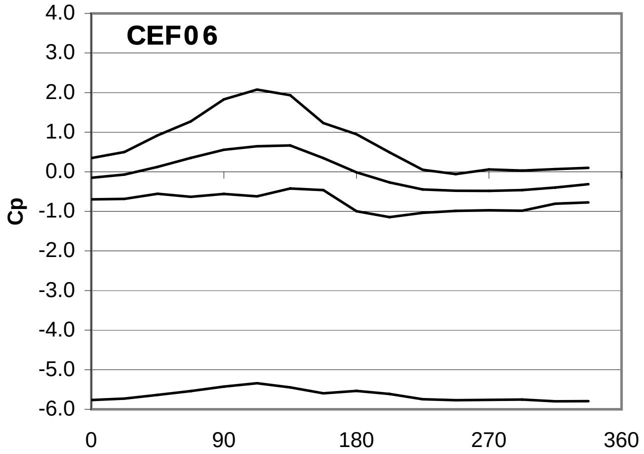
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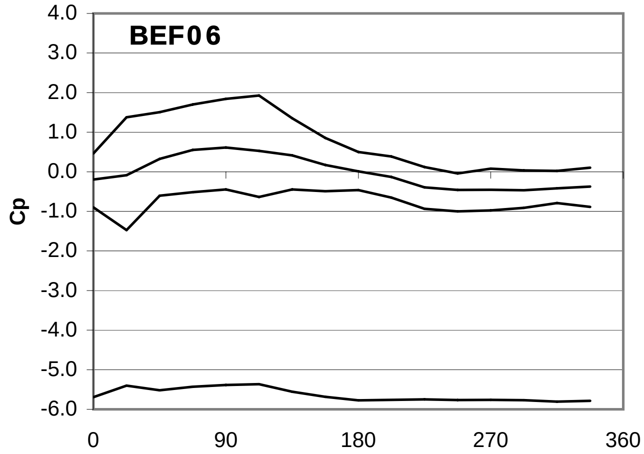
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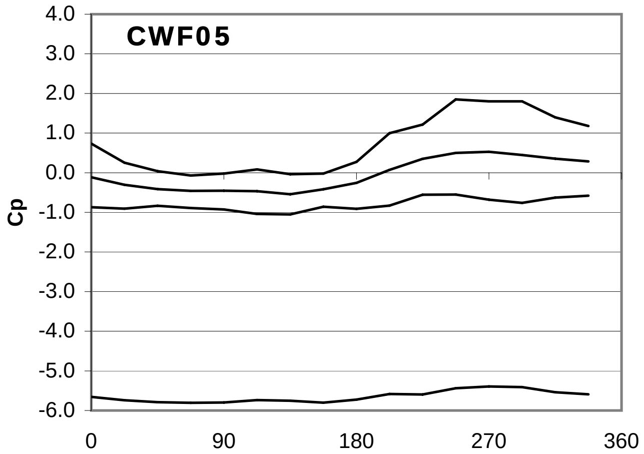
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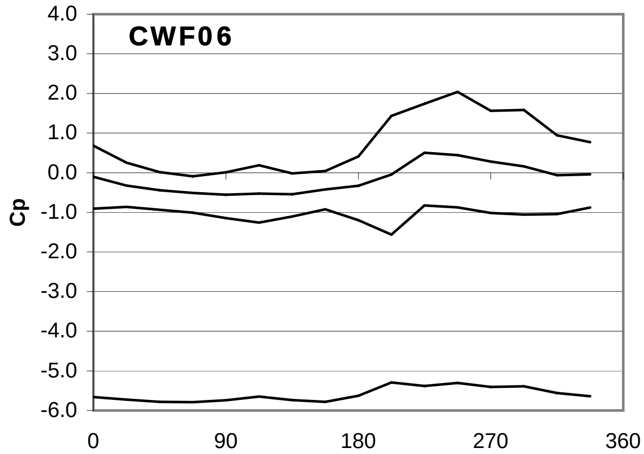
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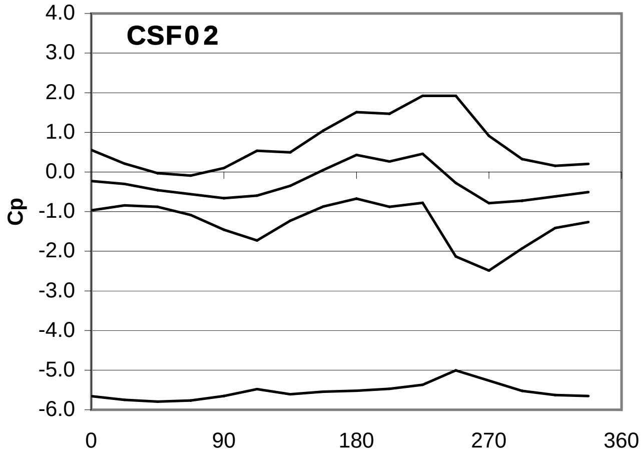
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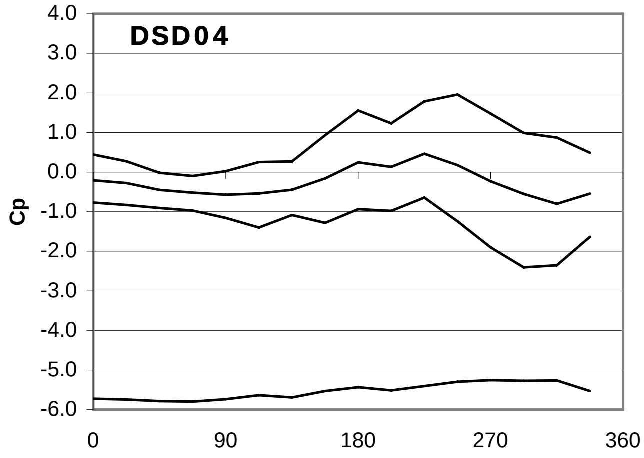
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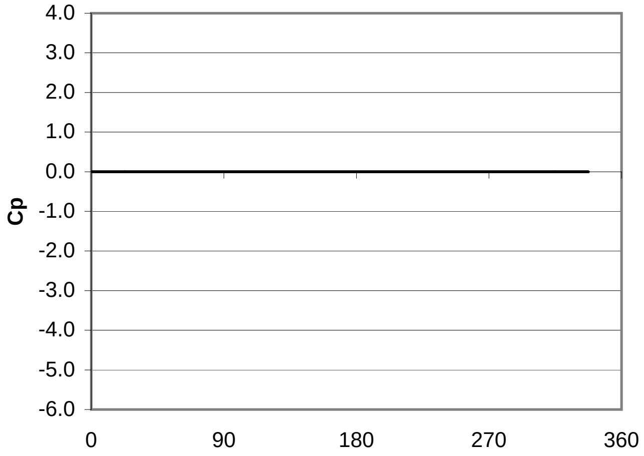
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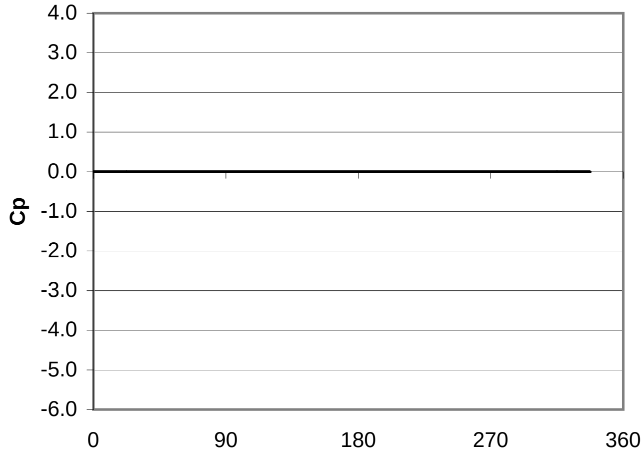
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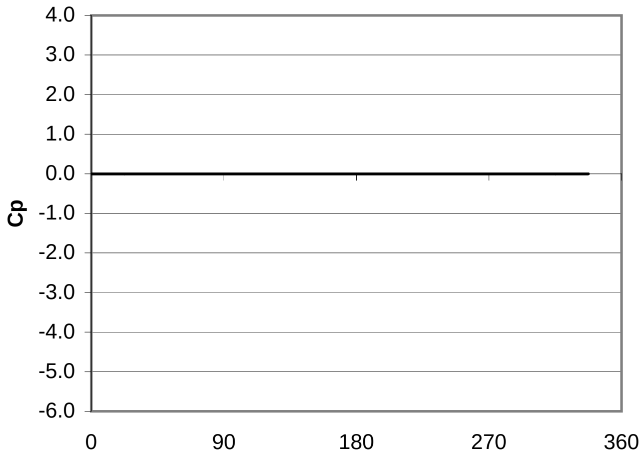
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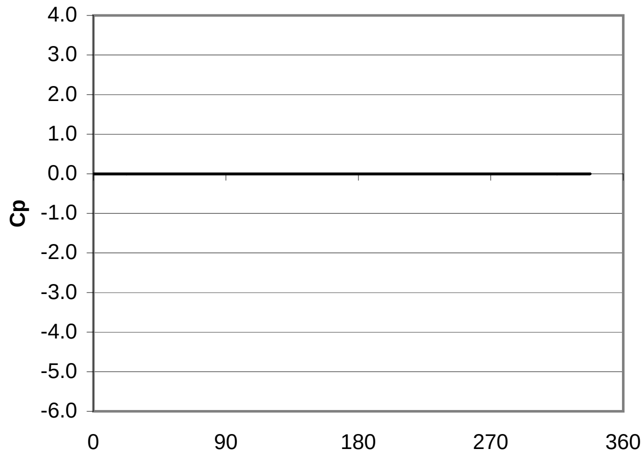
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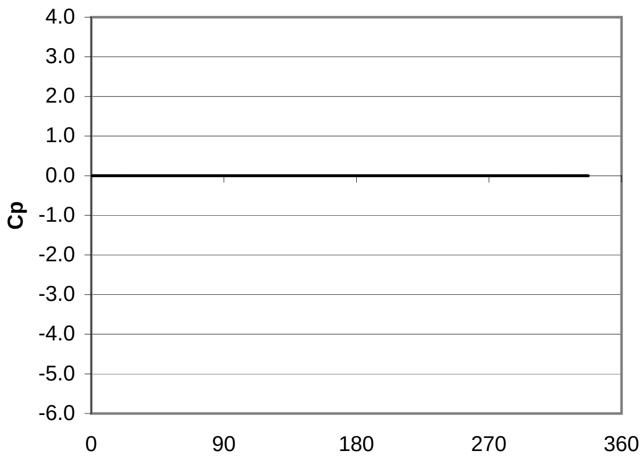
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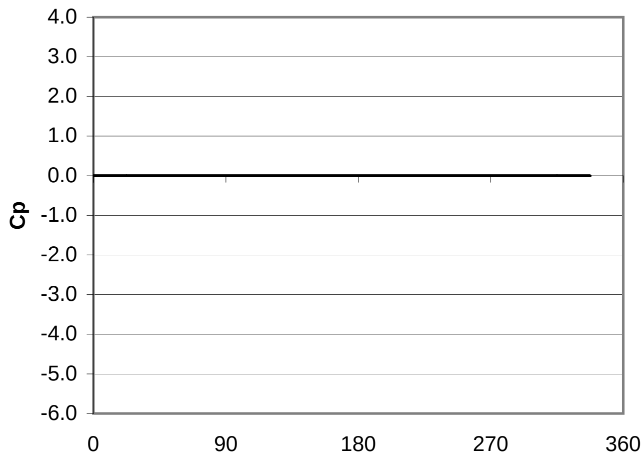
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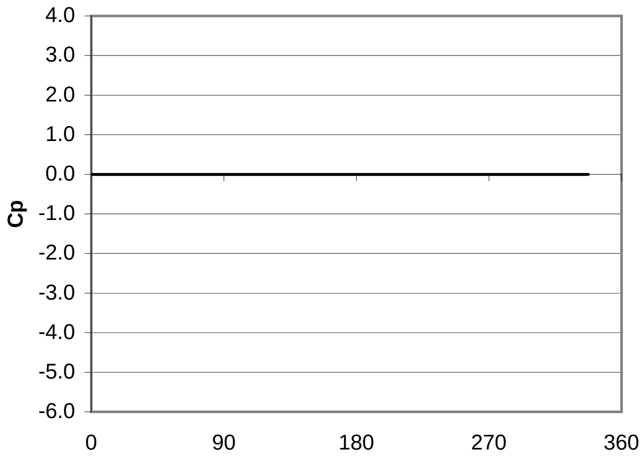

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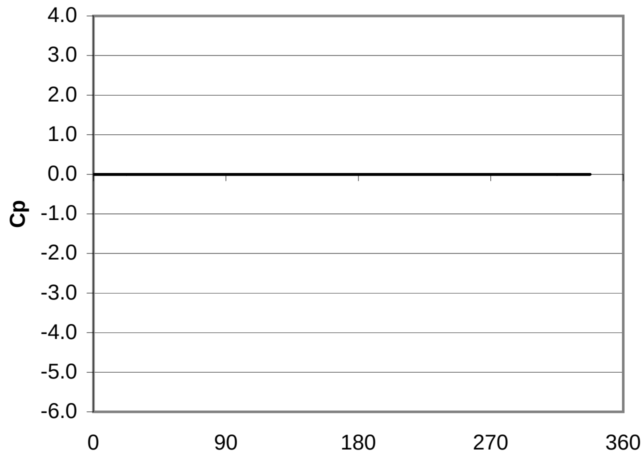

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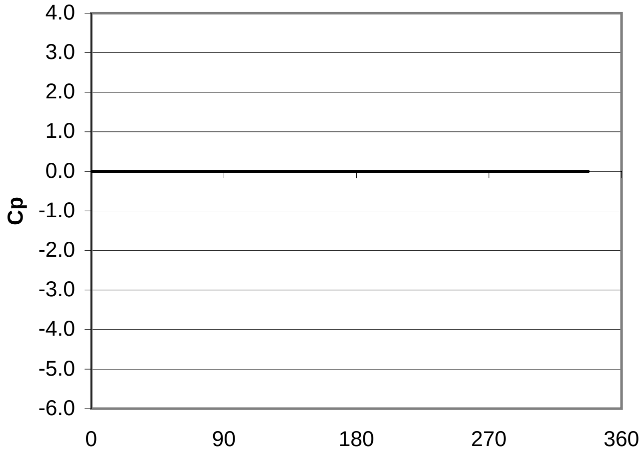

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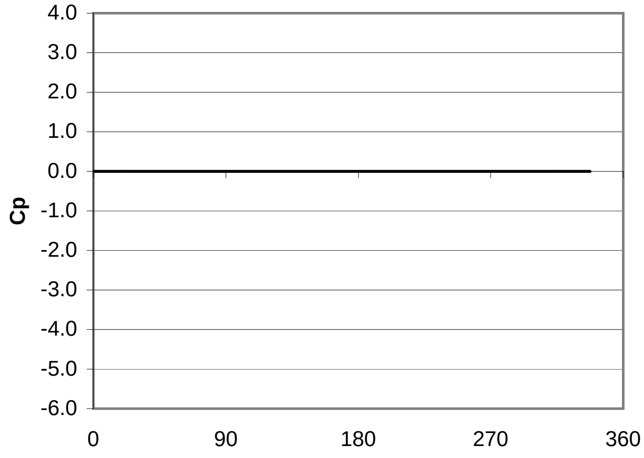

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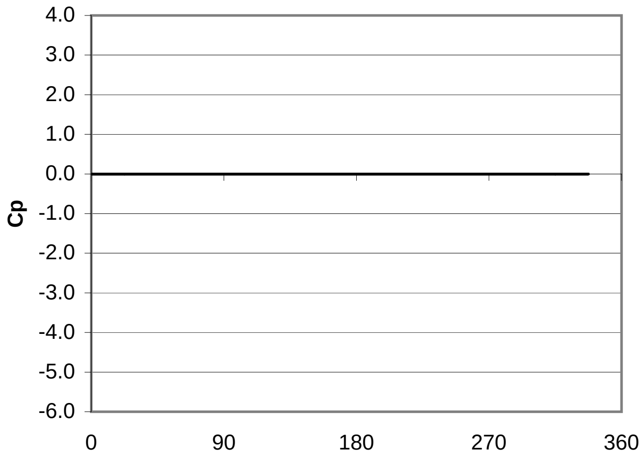

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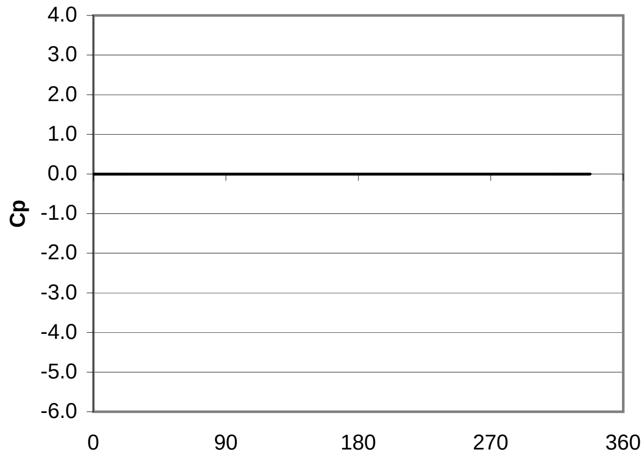

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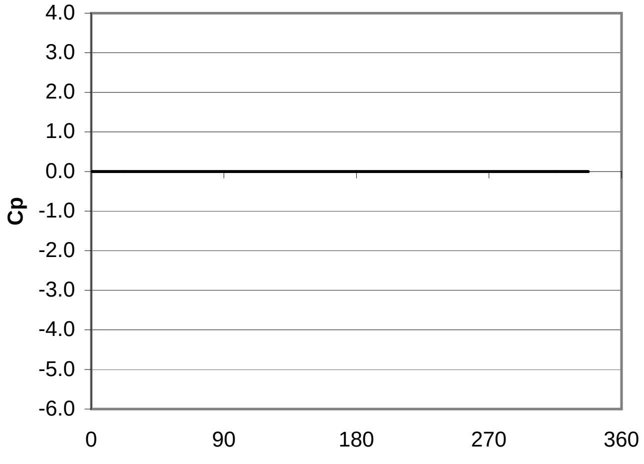

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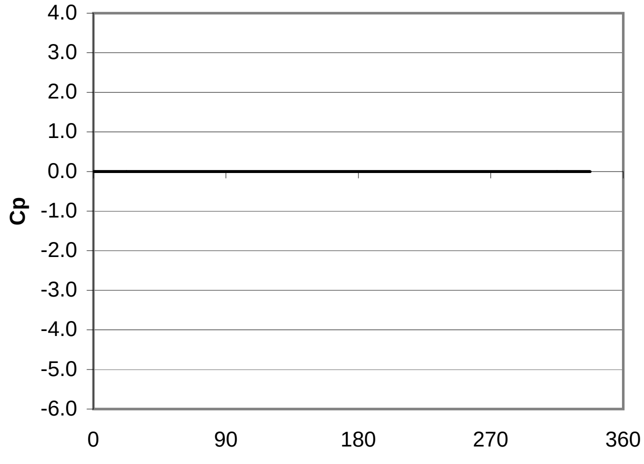

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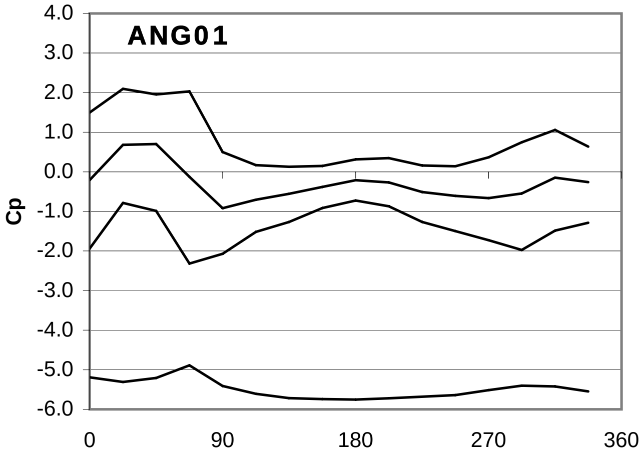
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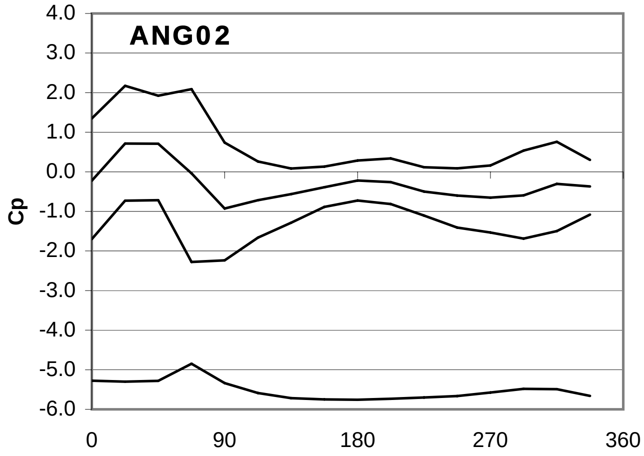
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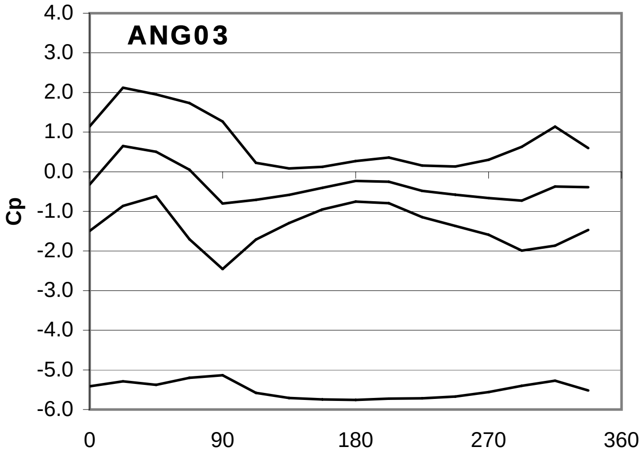
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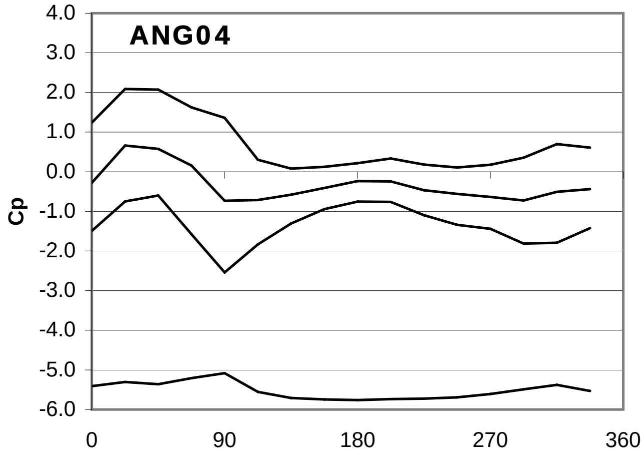
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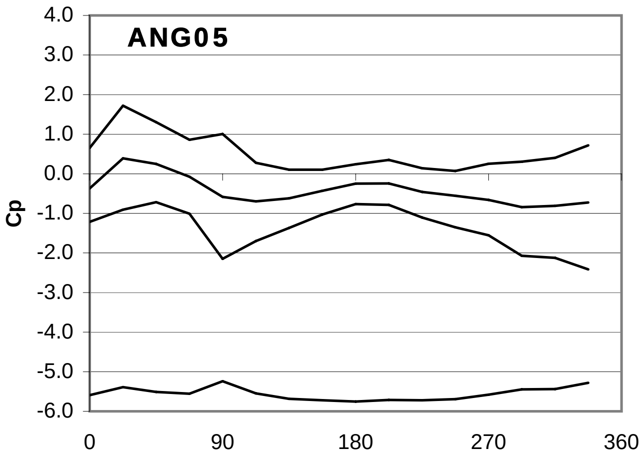
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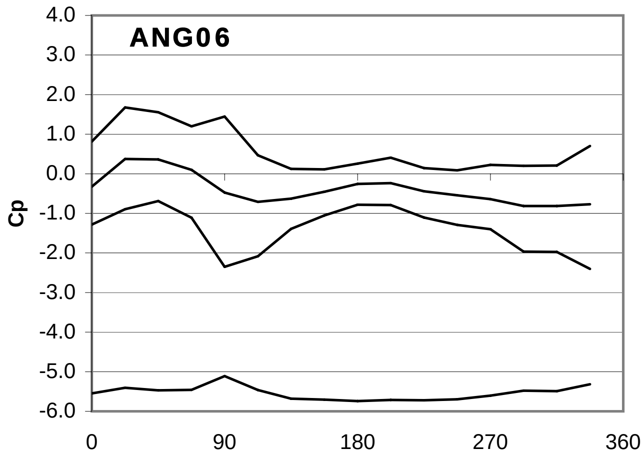
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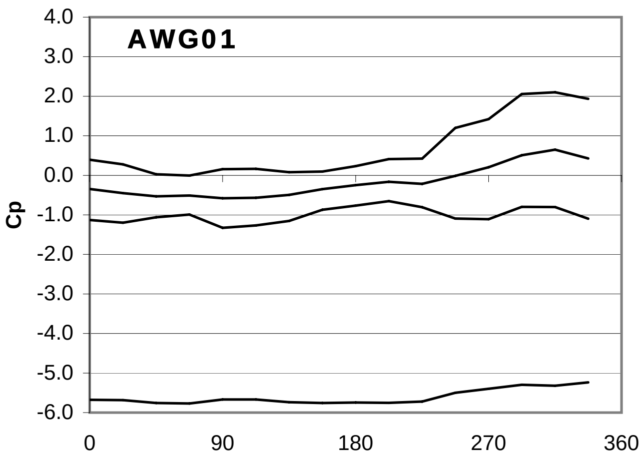
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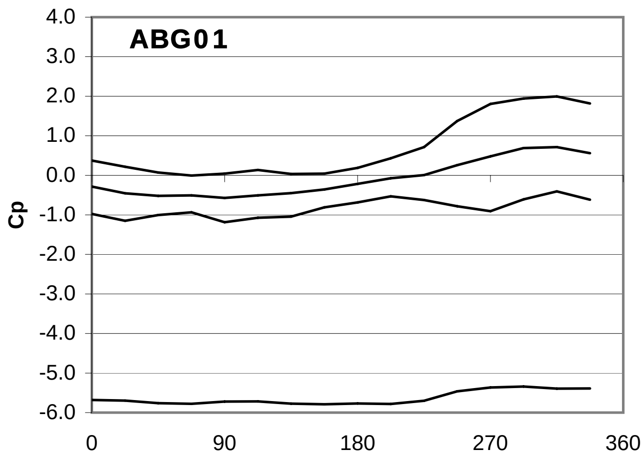
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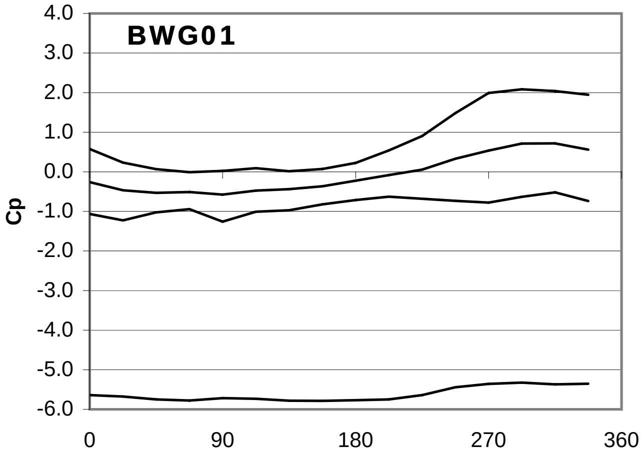
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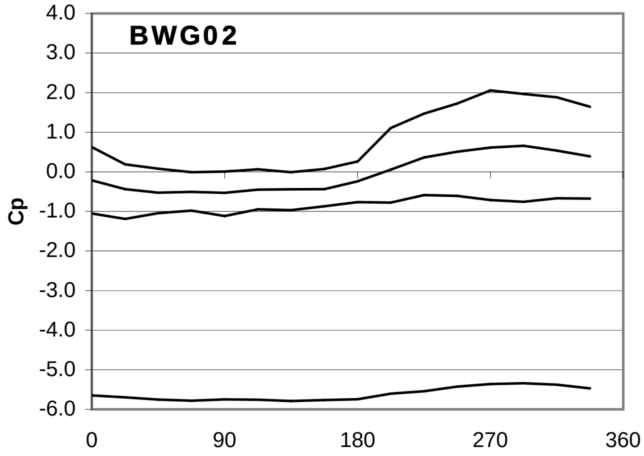
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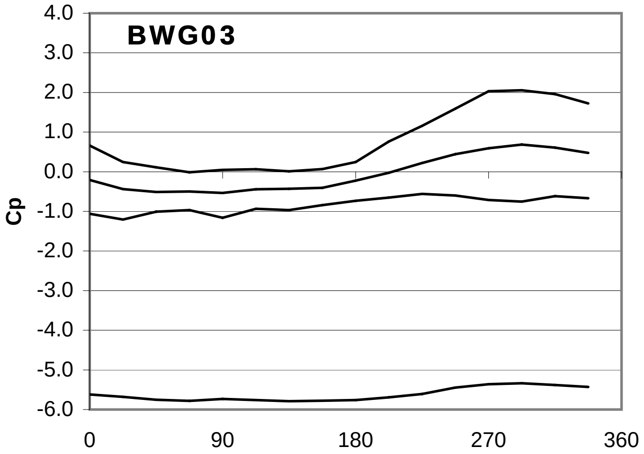
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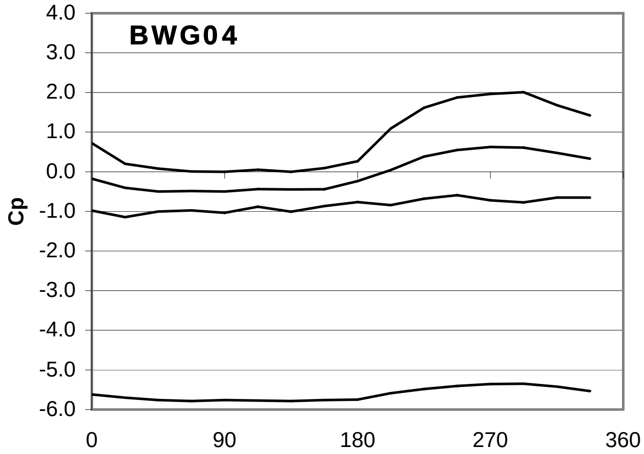
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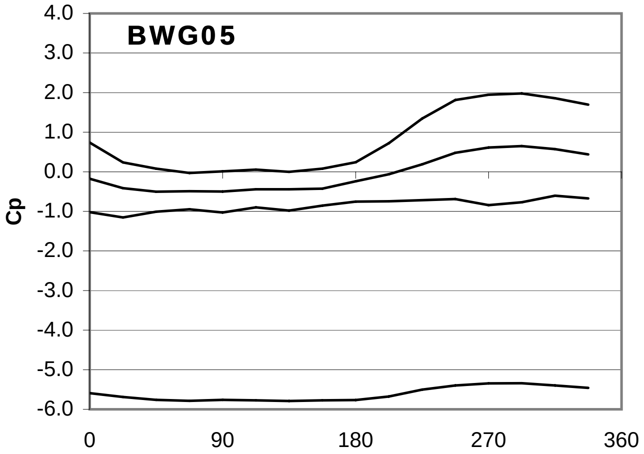
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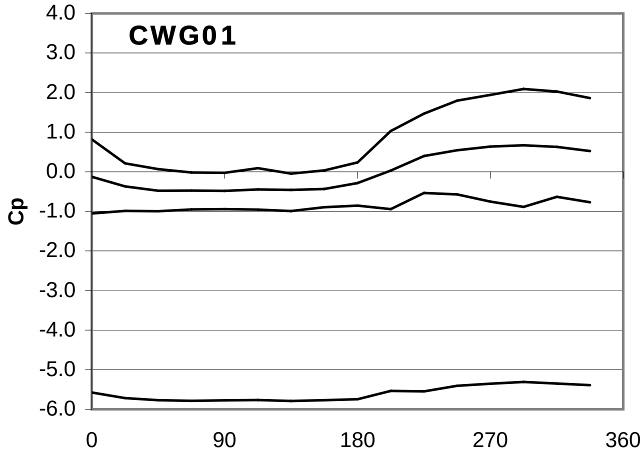
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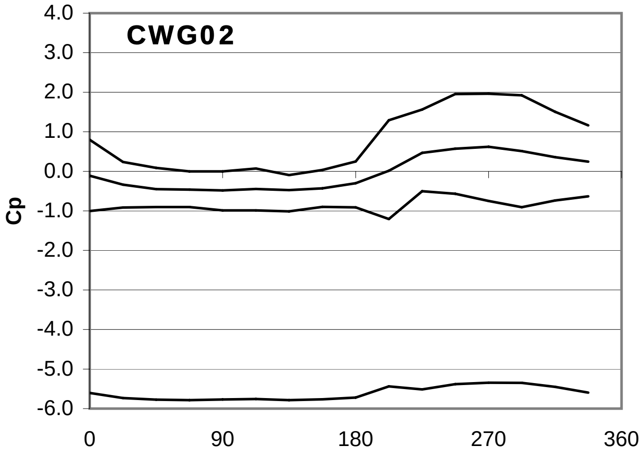
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CWG03
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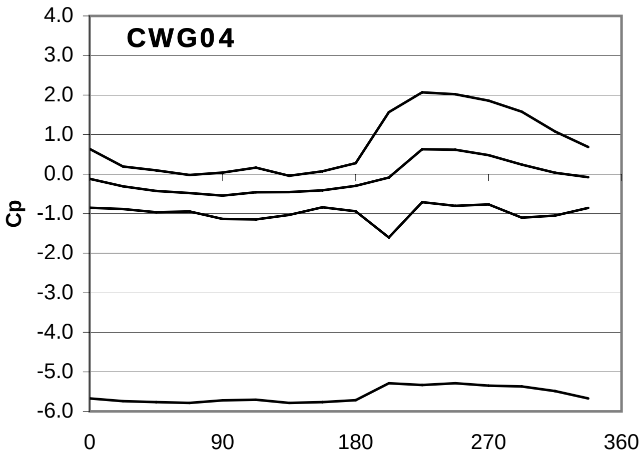
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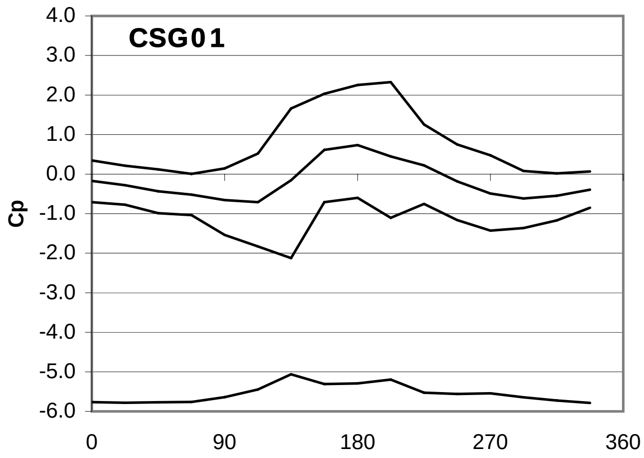
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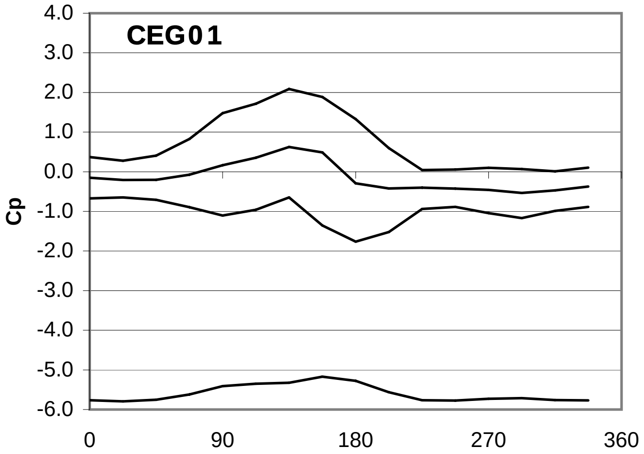
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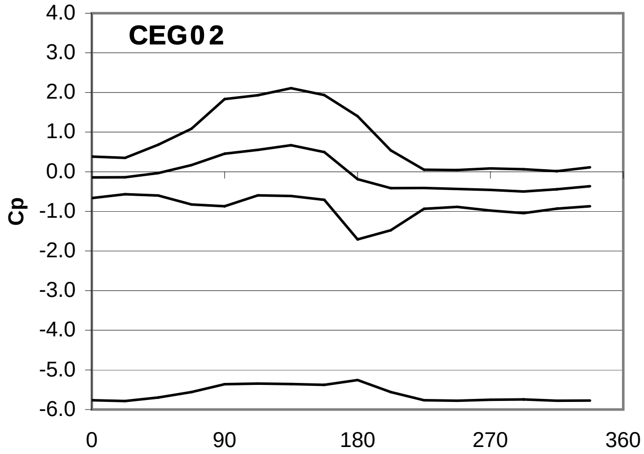
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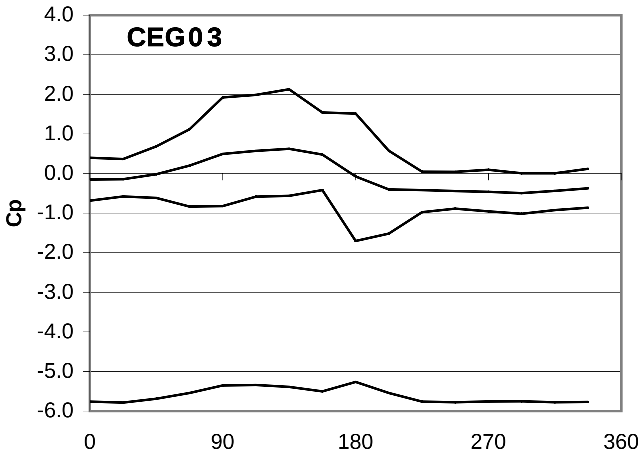
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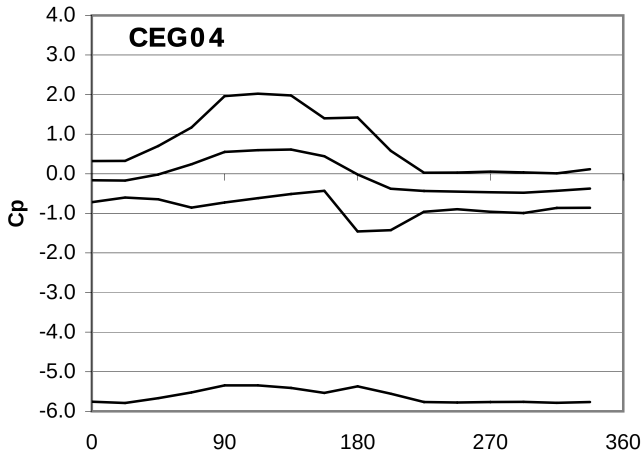
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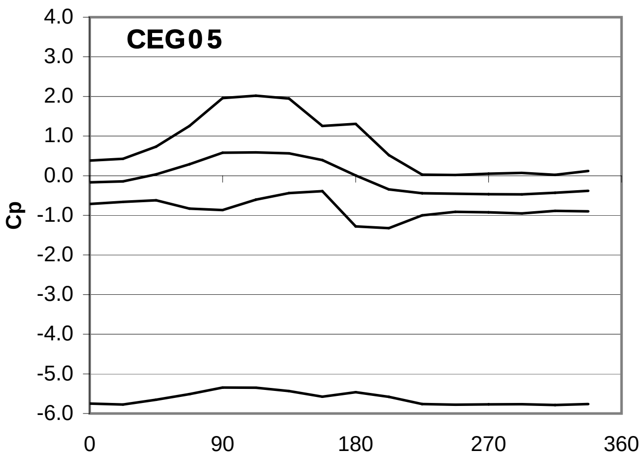
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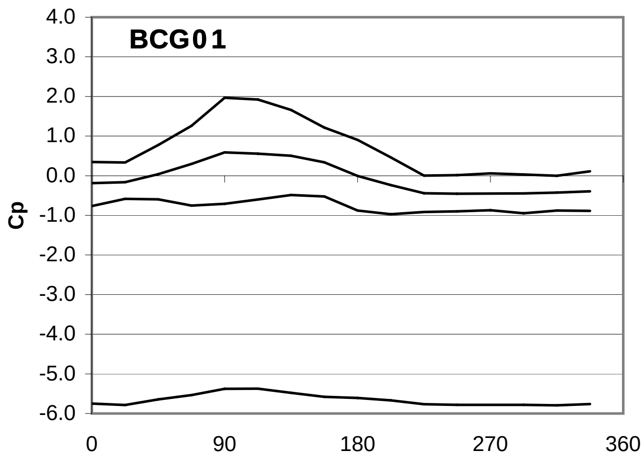
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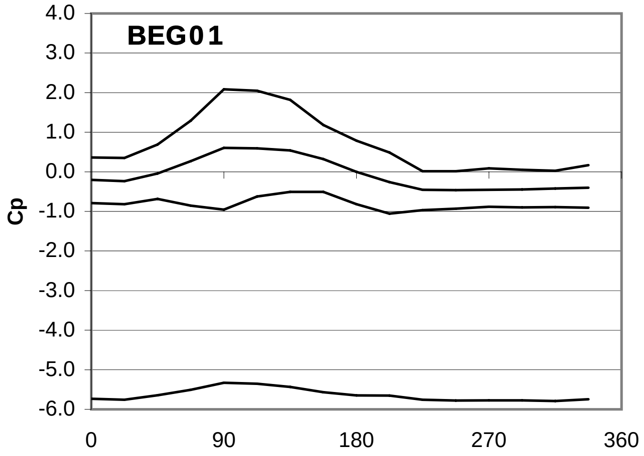
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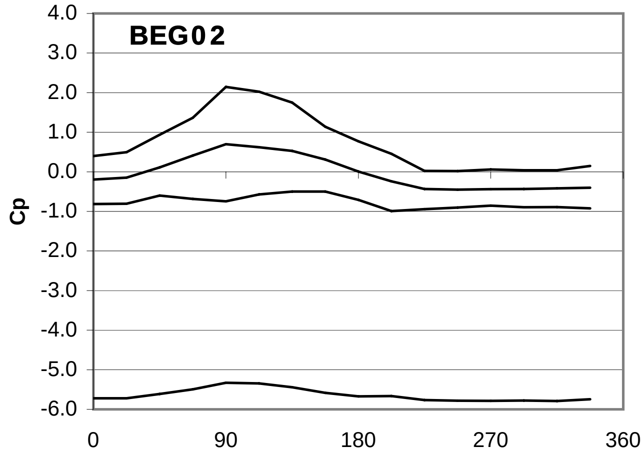
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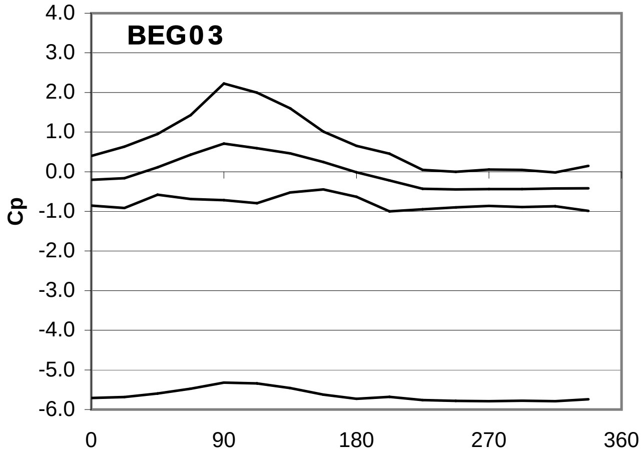
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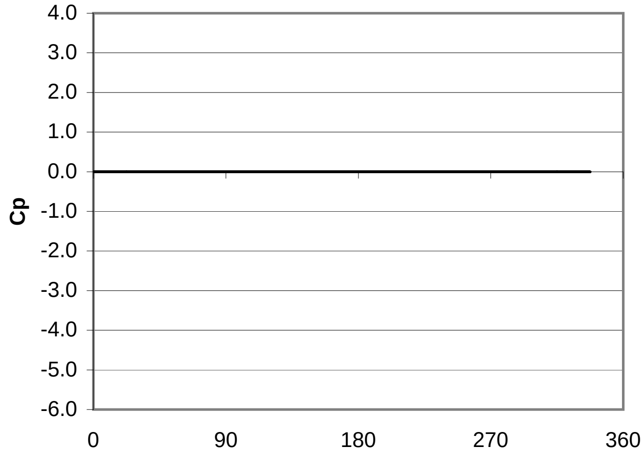
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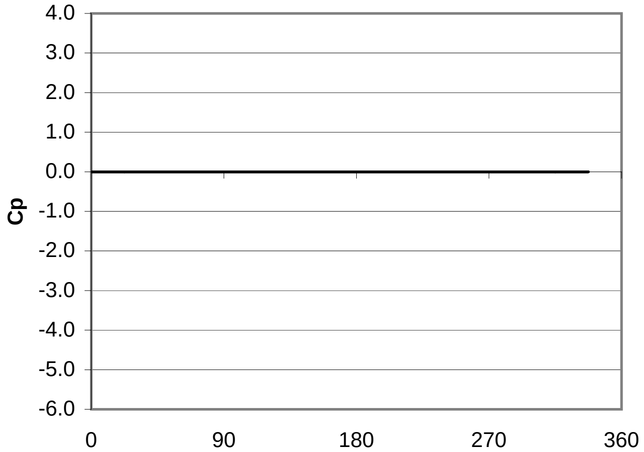
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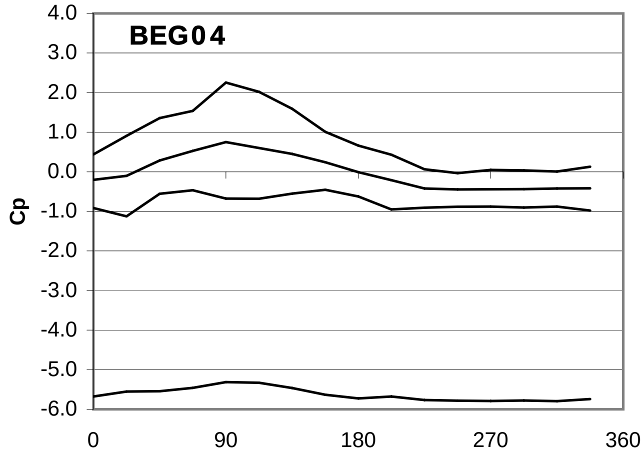
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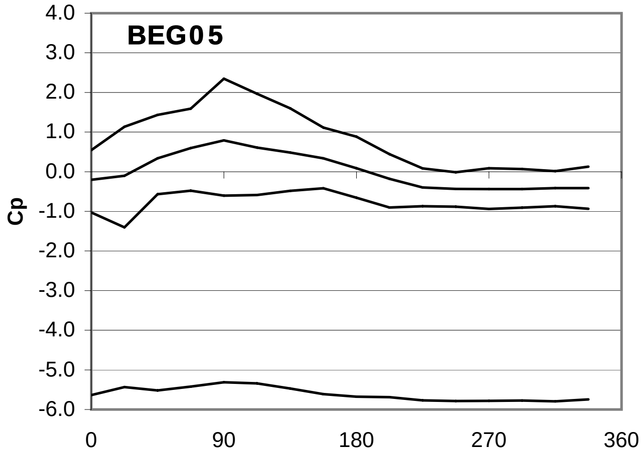
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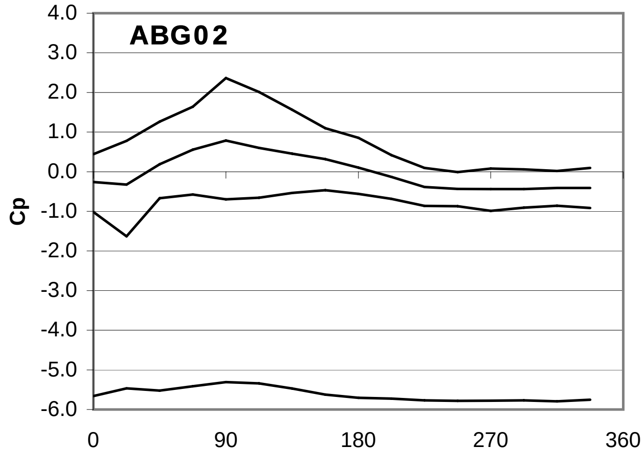
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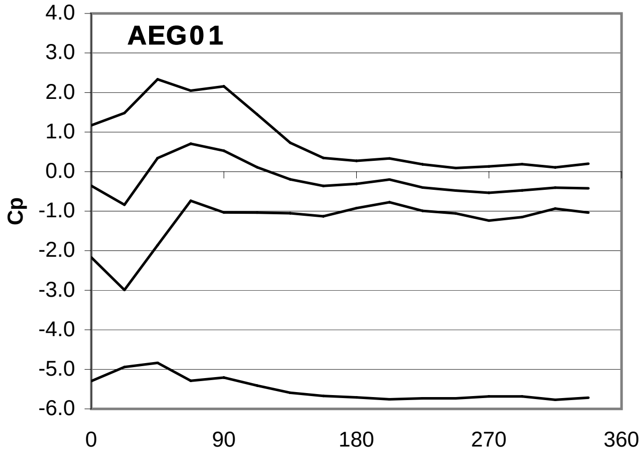
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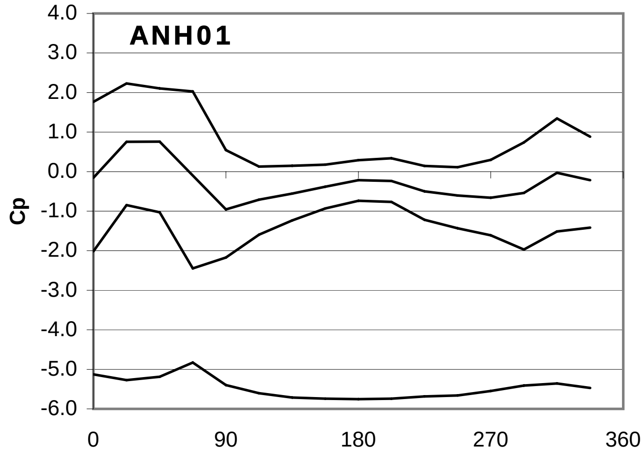
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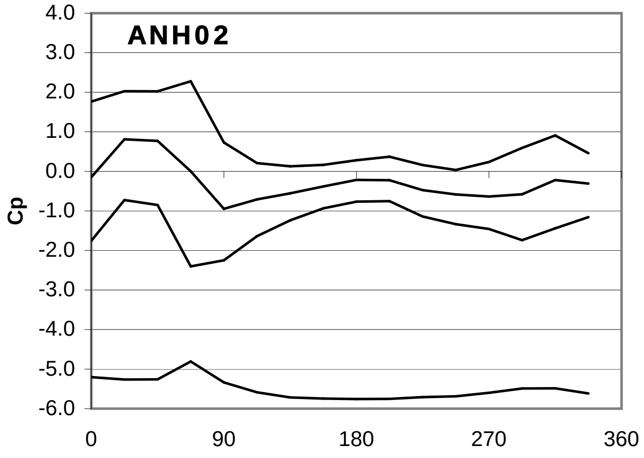
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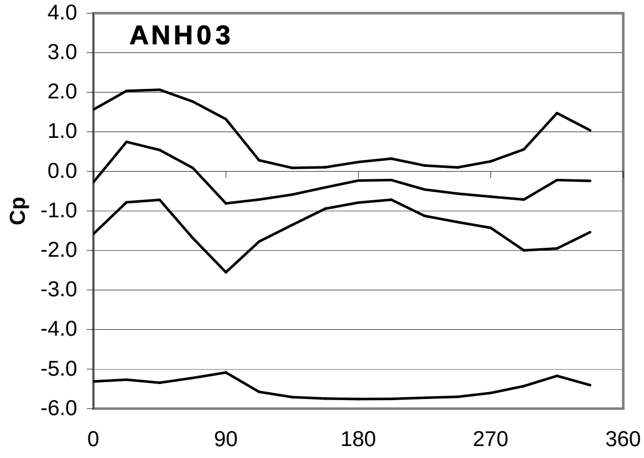
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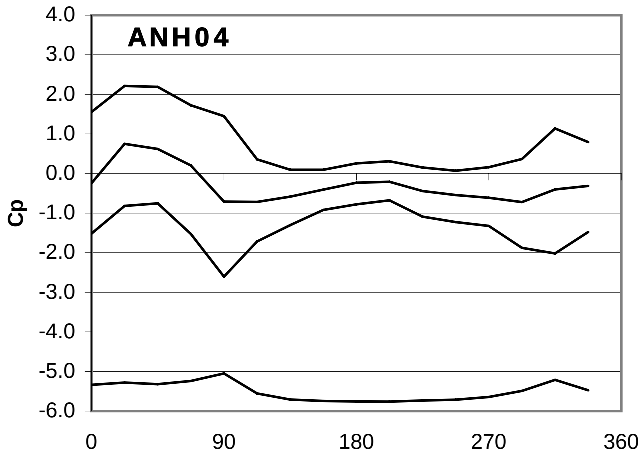
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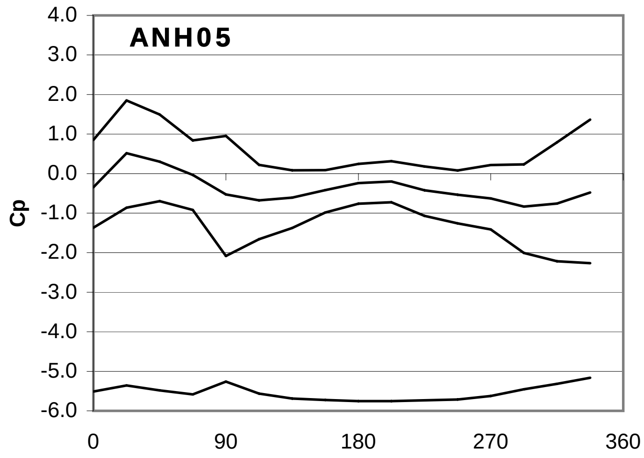
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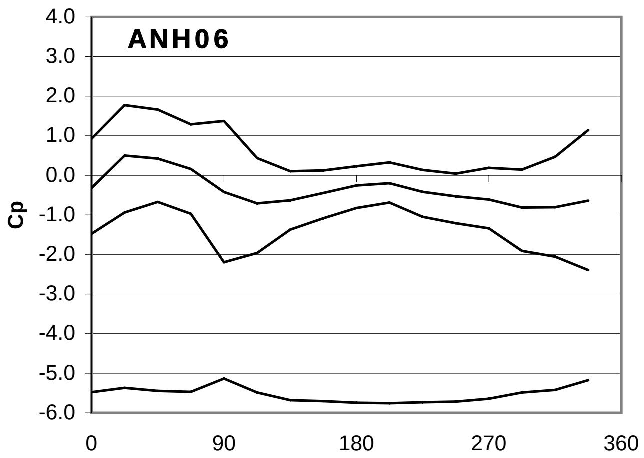
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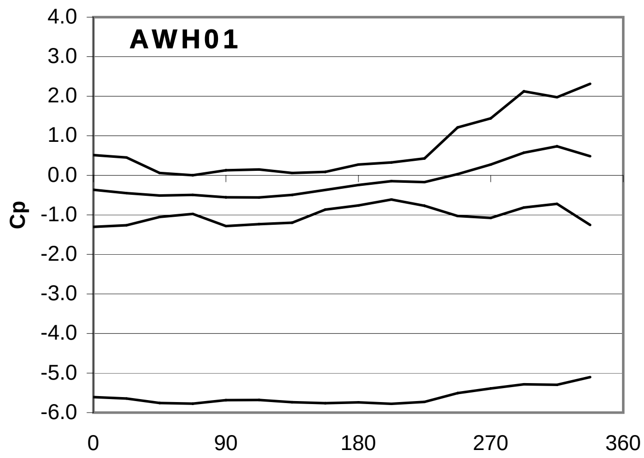
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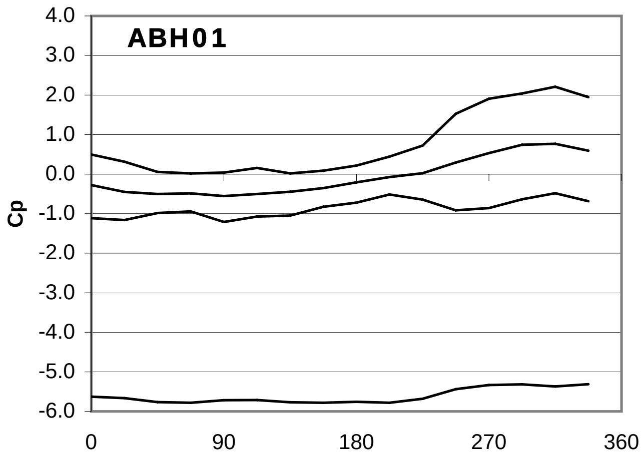
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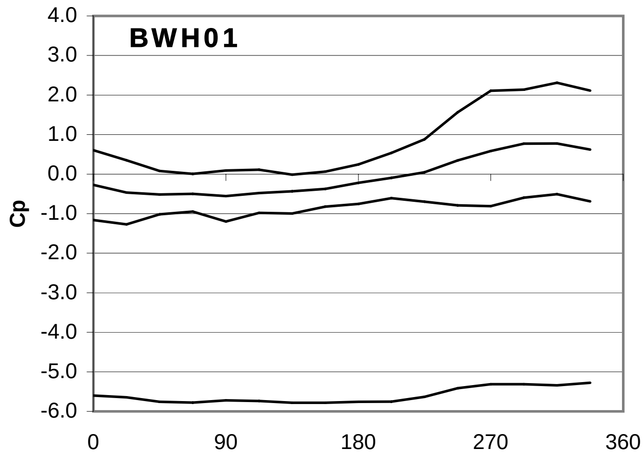
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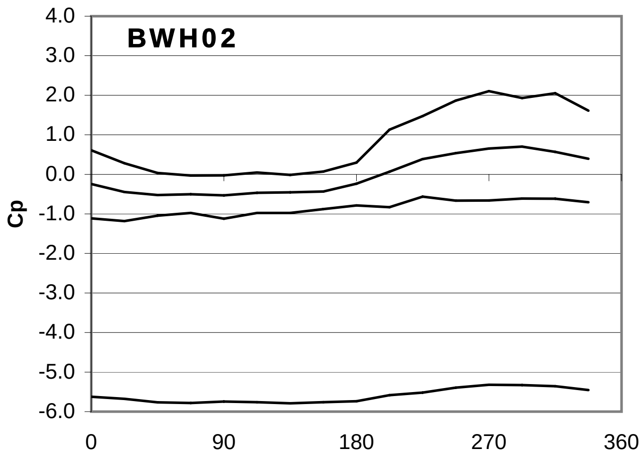
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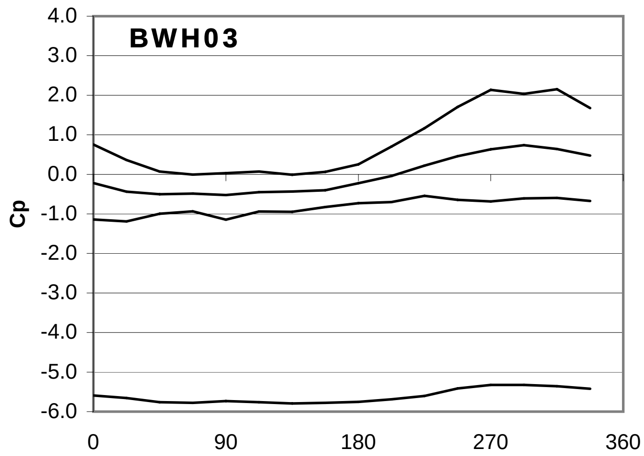
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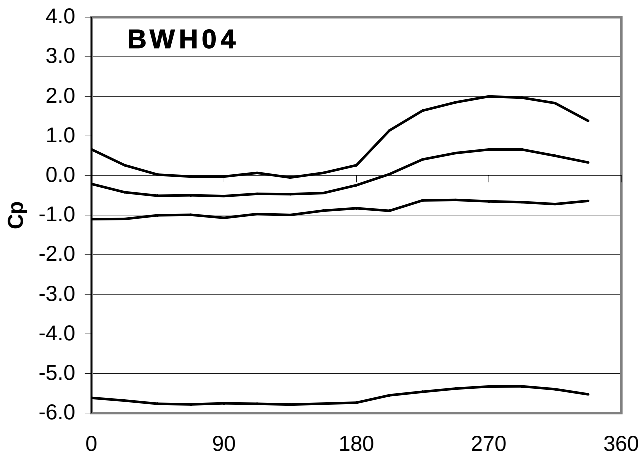
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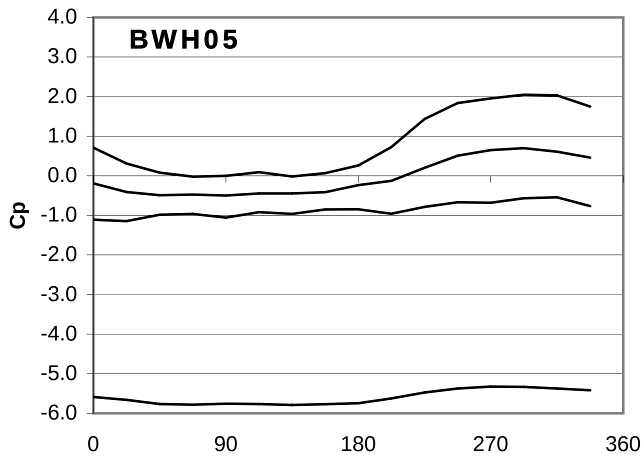
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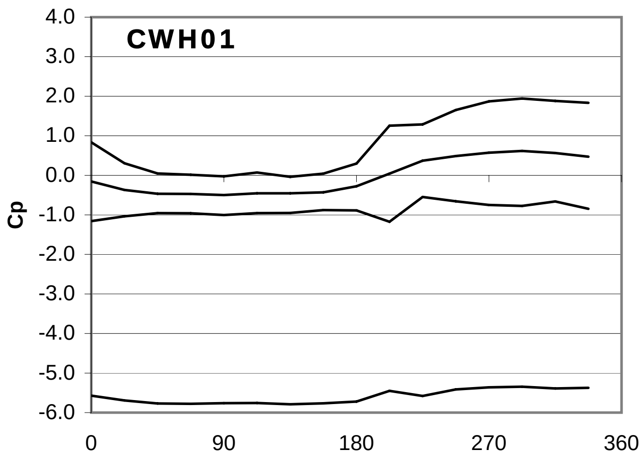
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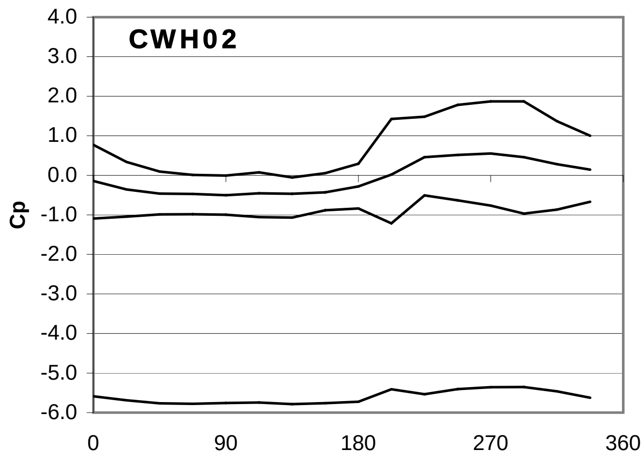
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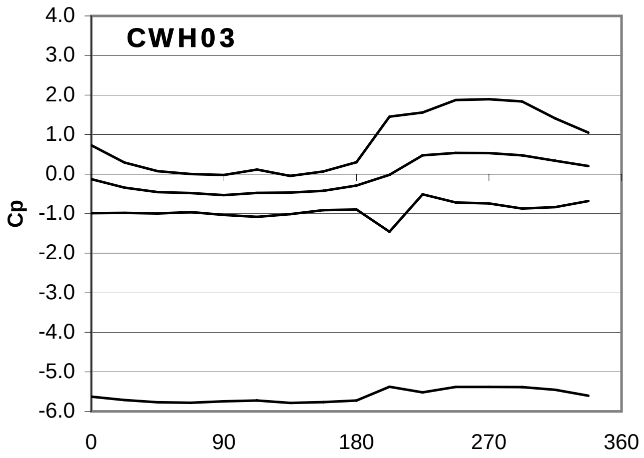
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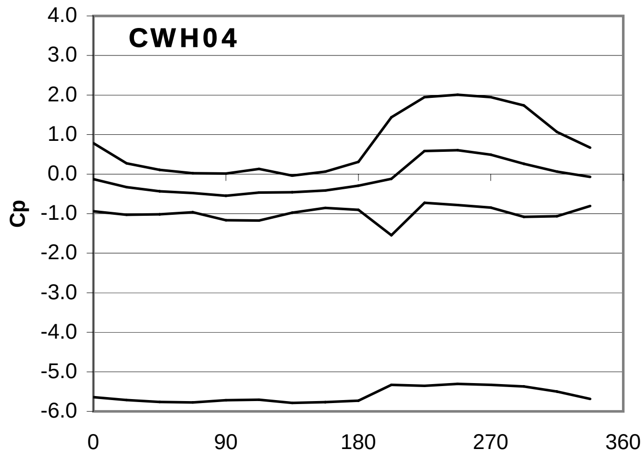
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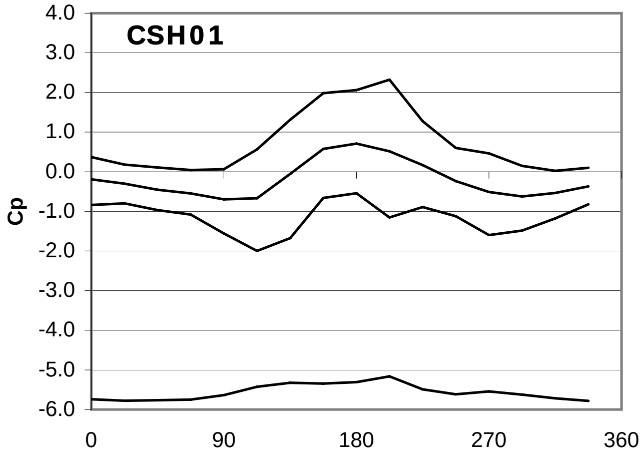
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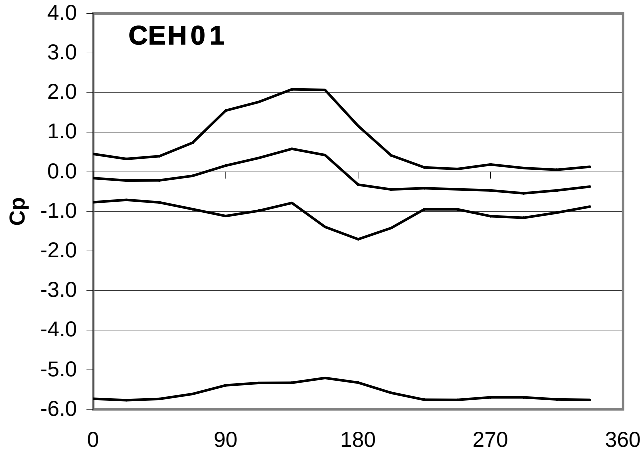
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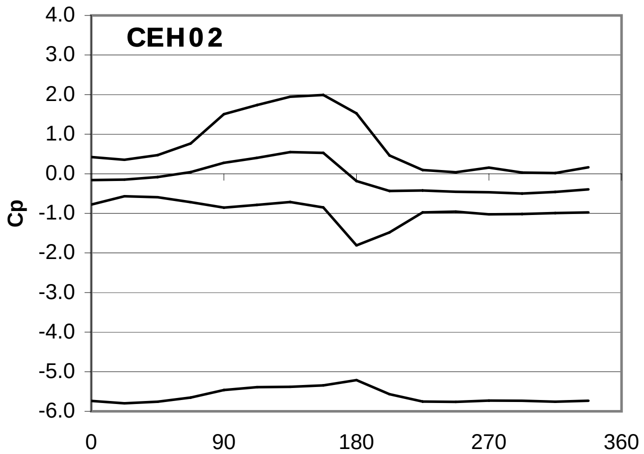
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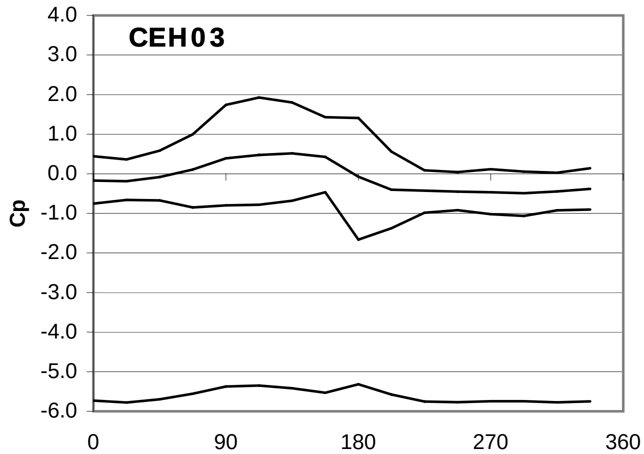
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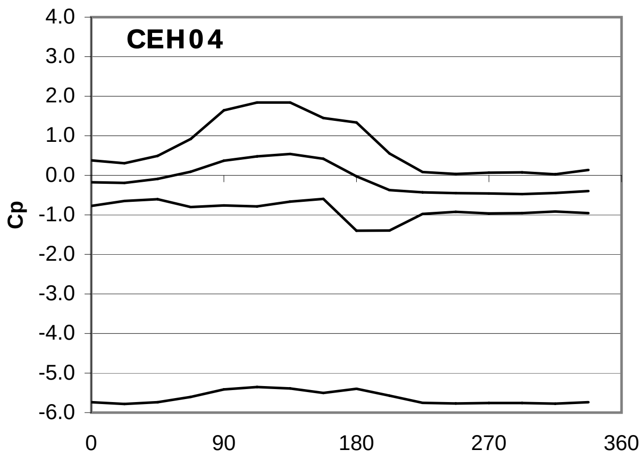
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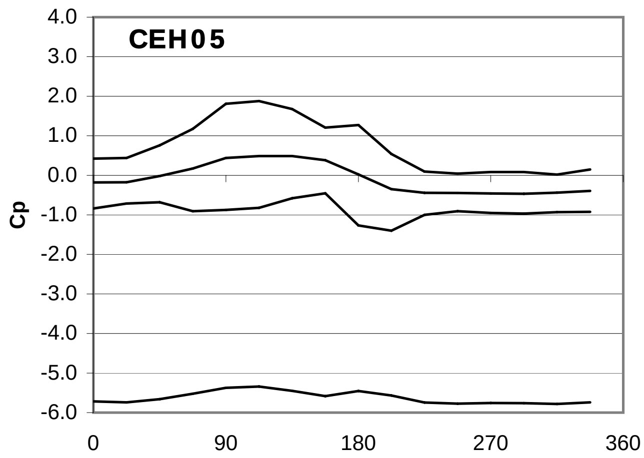
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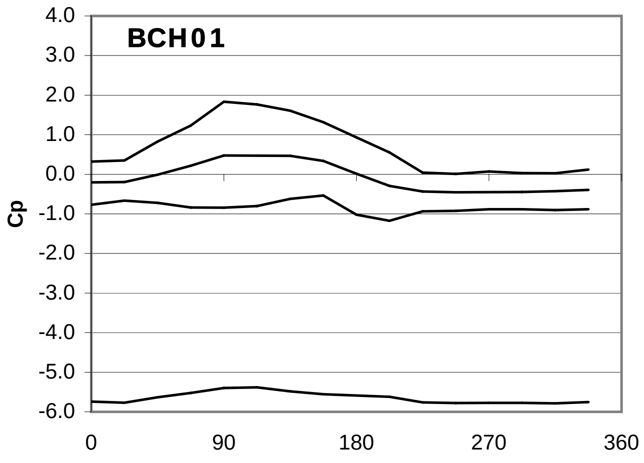
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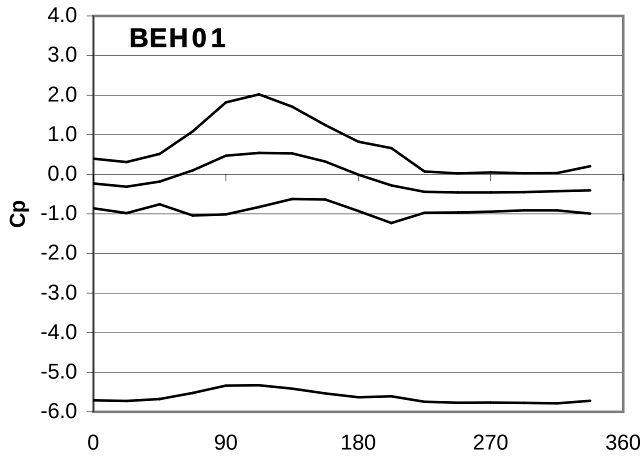
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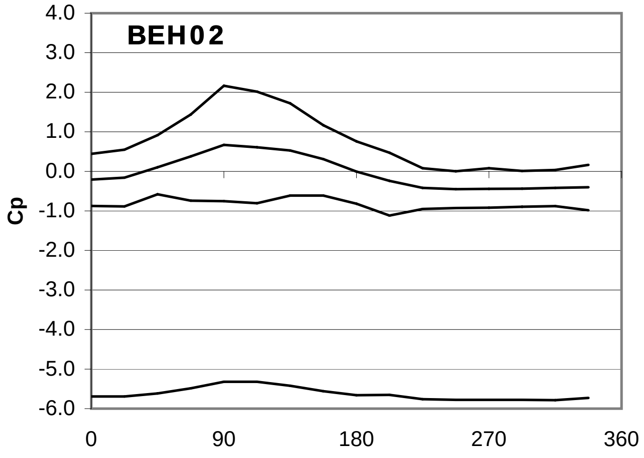
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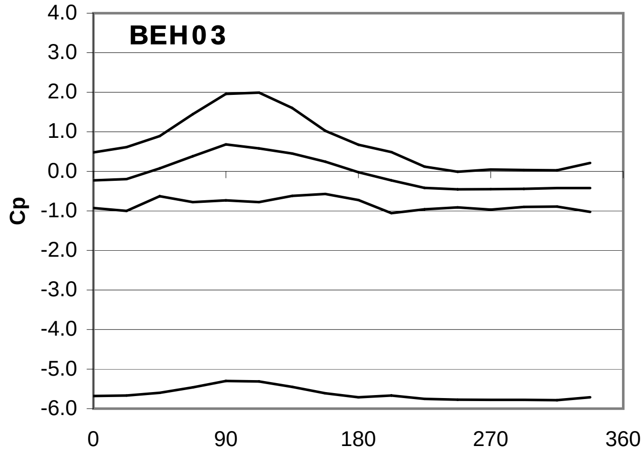
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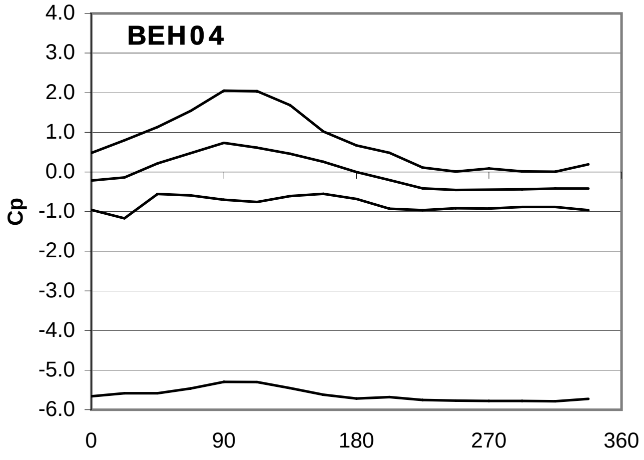
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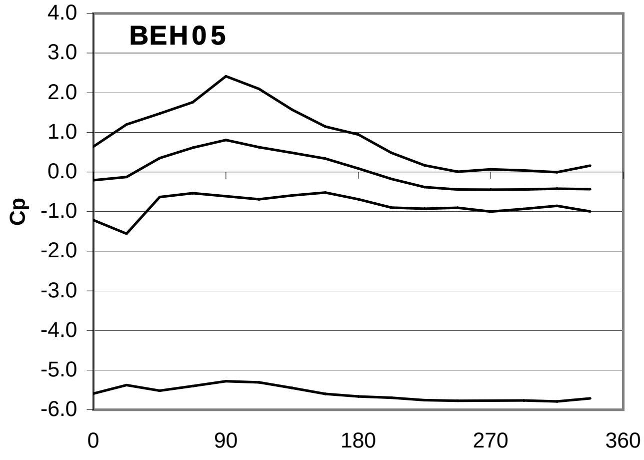
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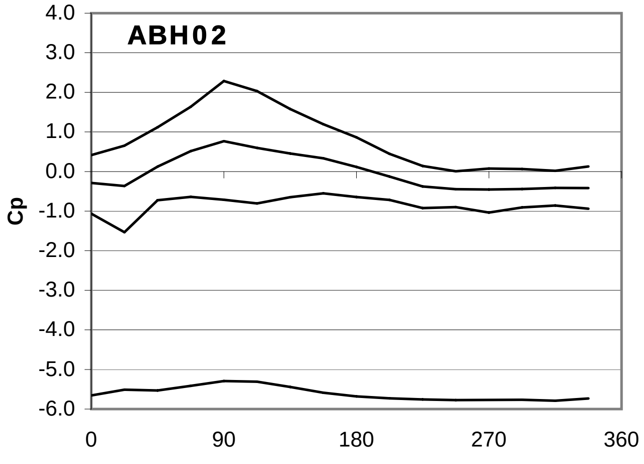
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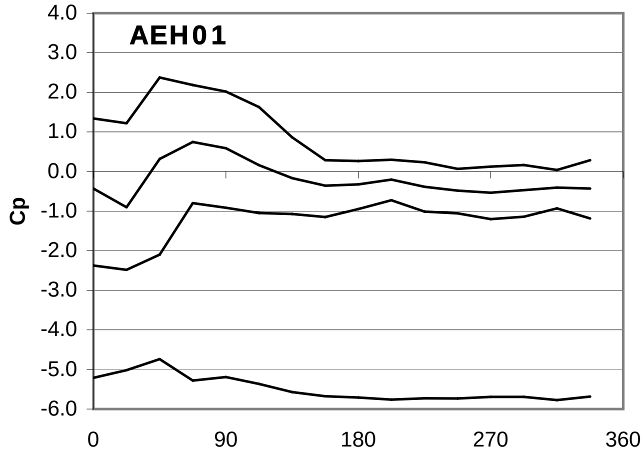
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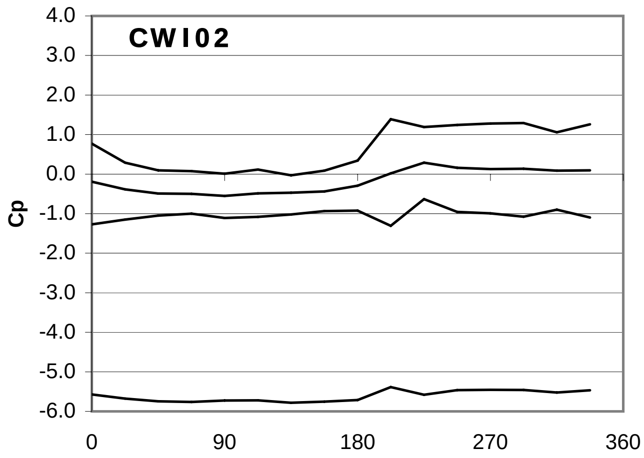
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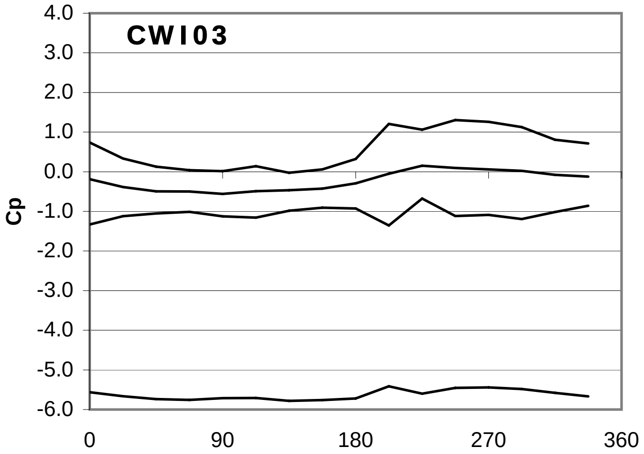
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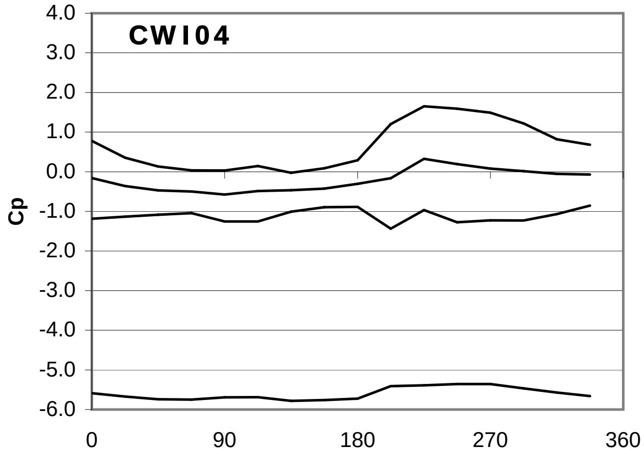
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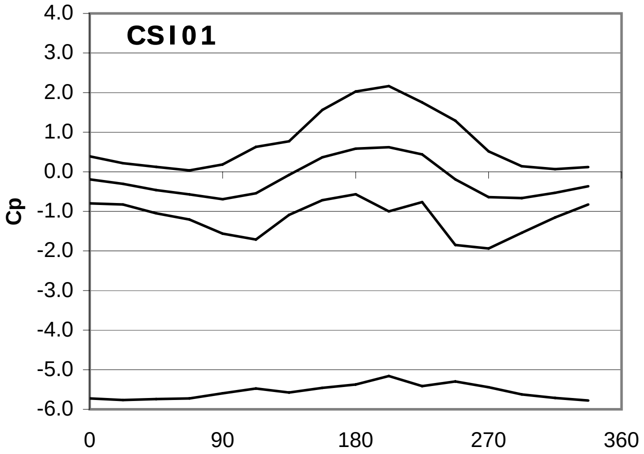
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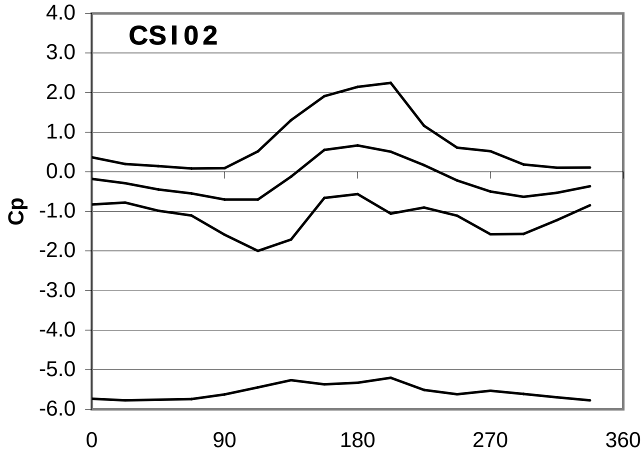
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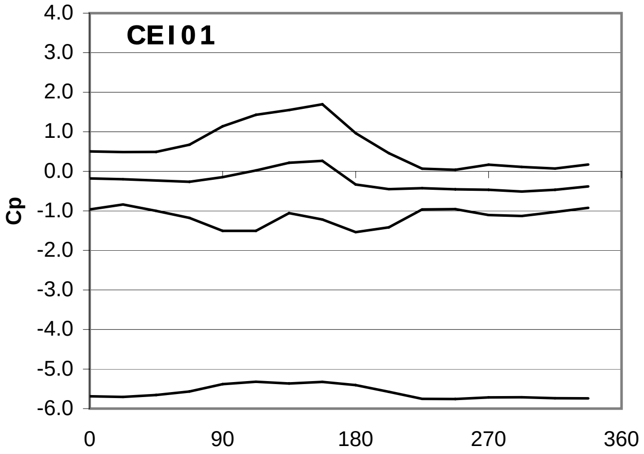
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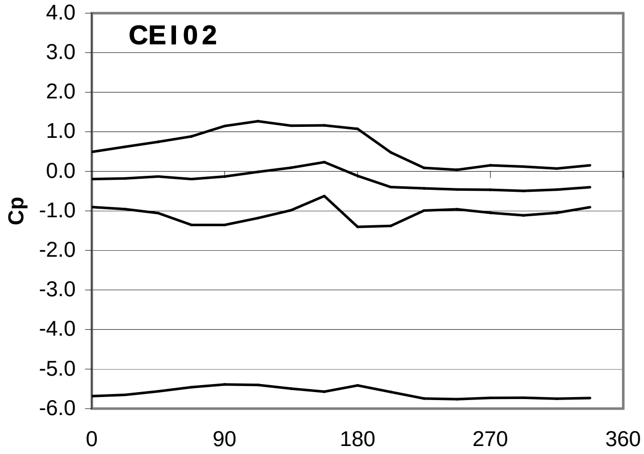
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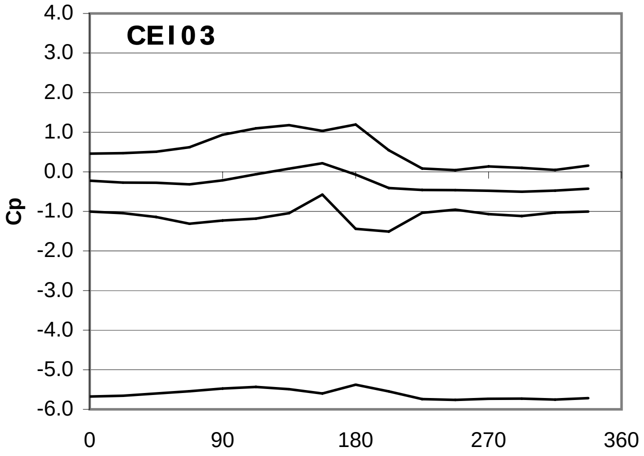
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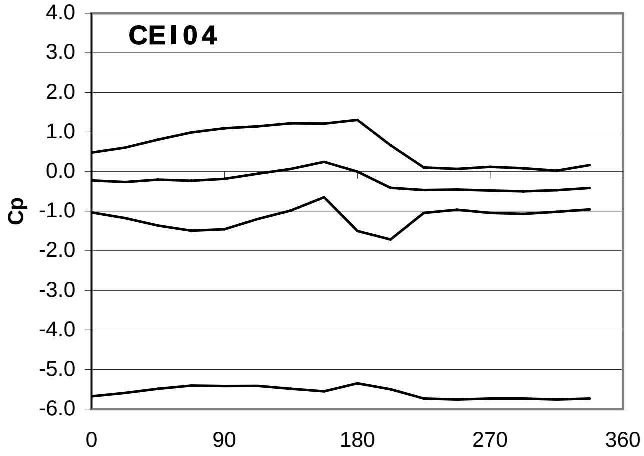
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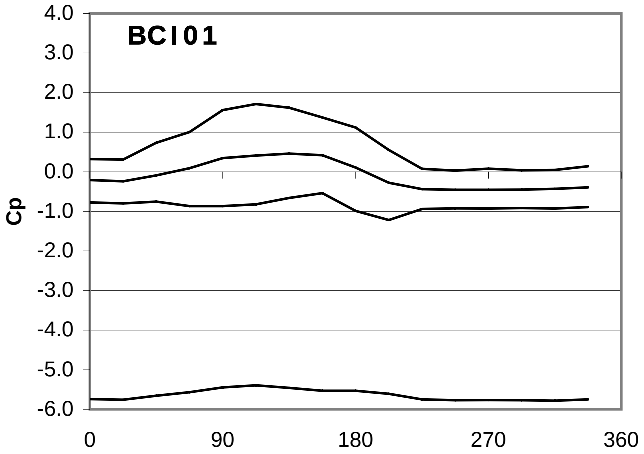
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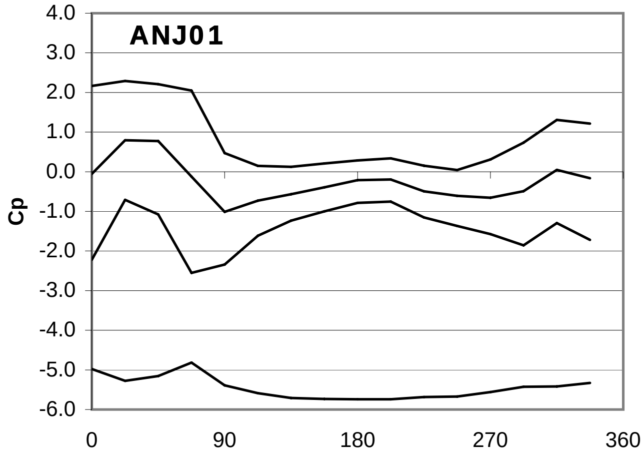
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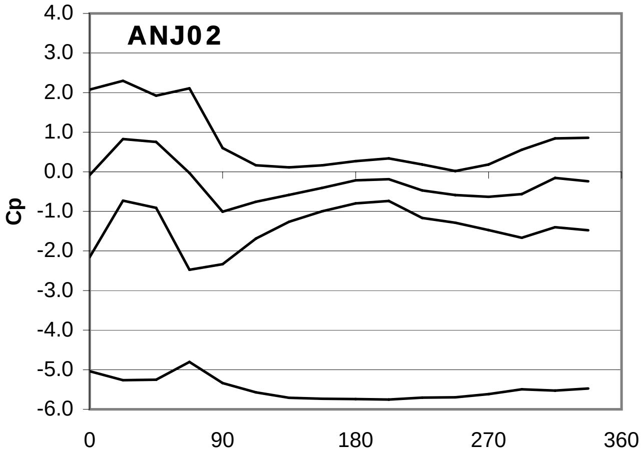
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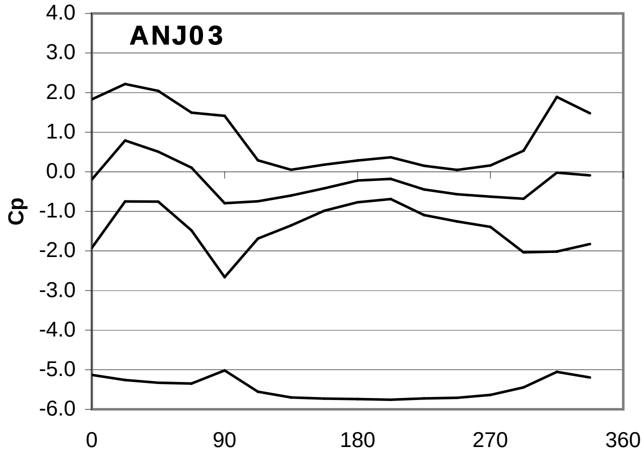
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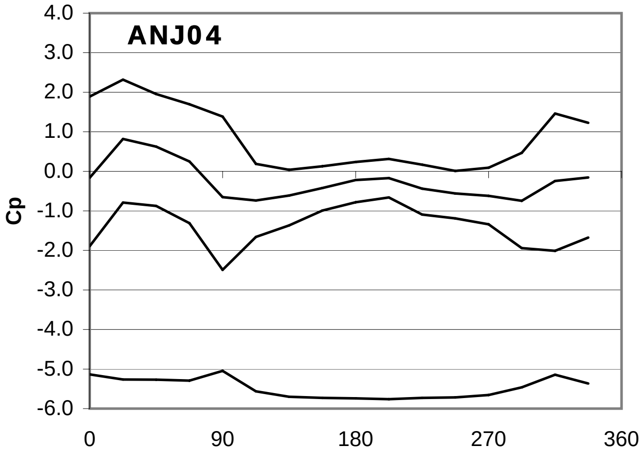
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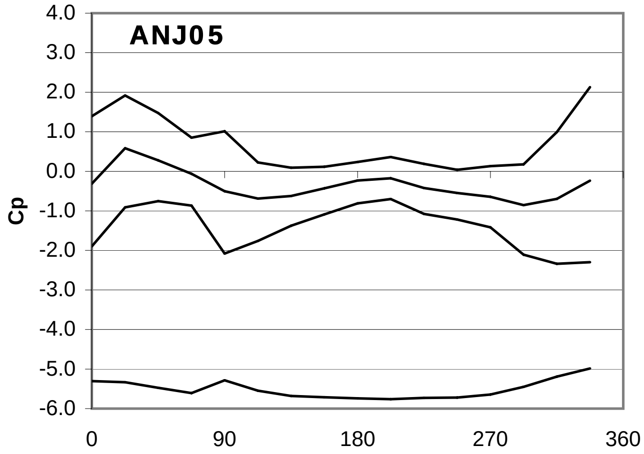
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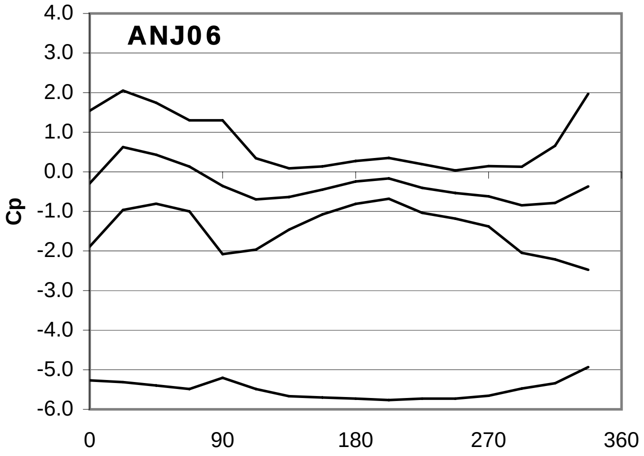
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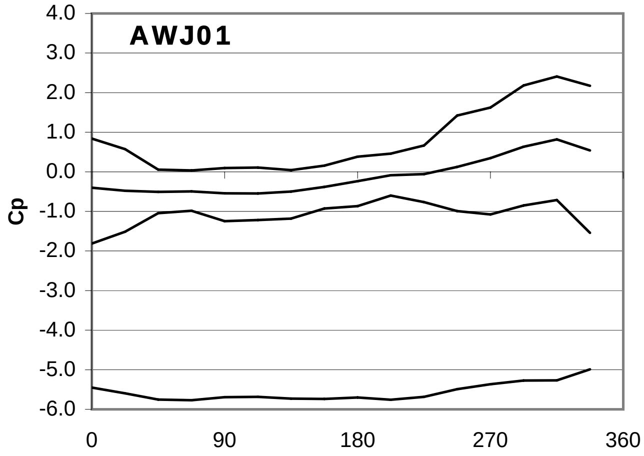
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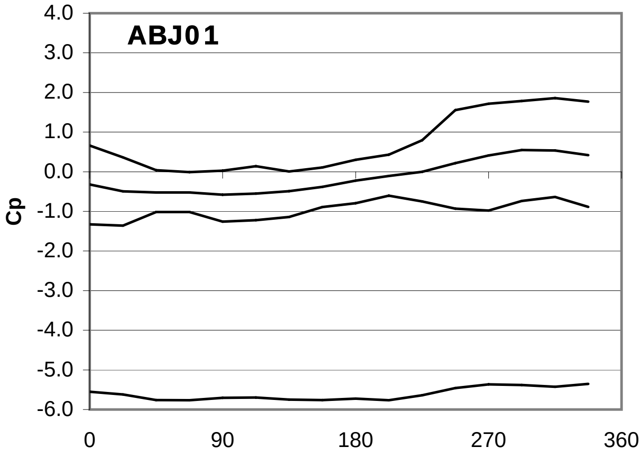
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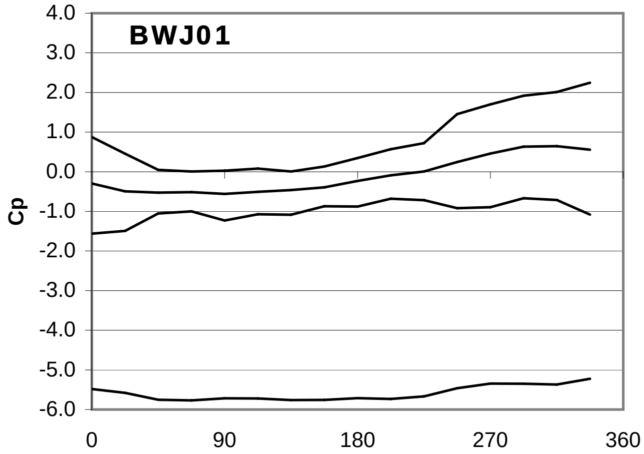
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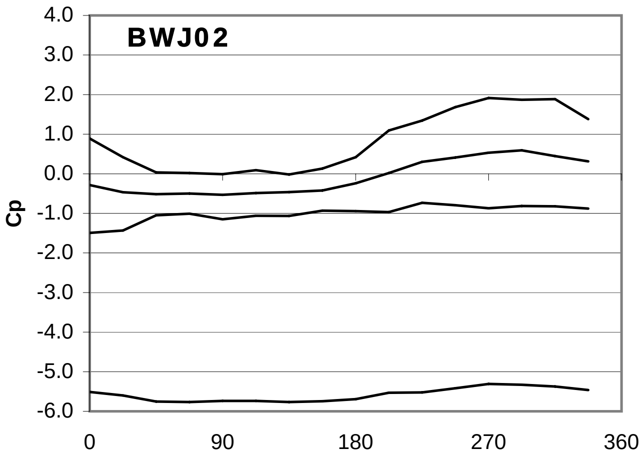
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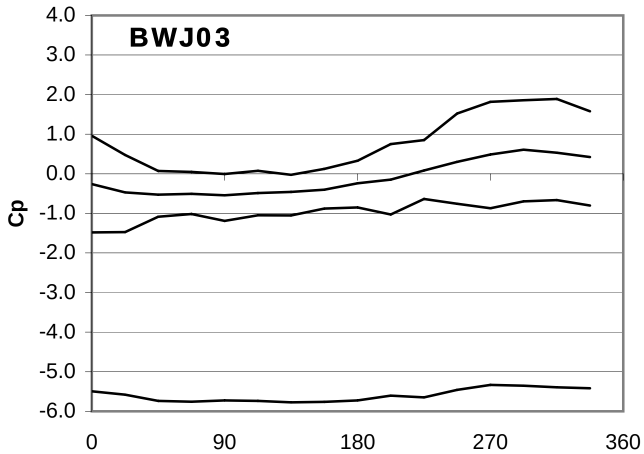
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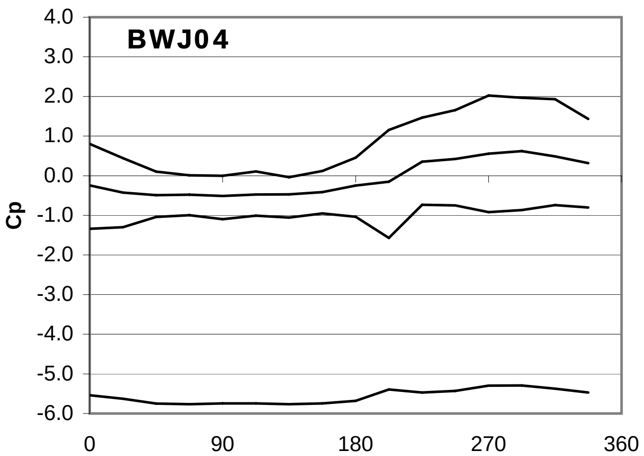
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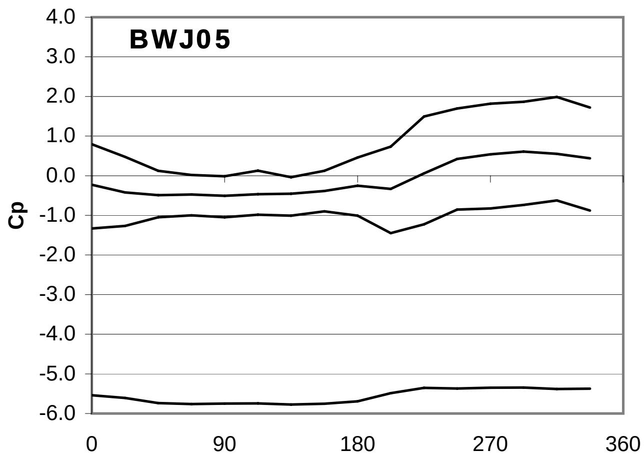
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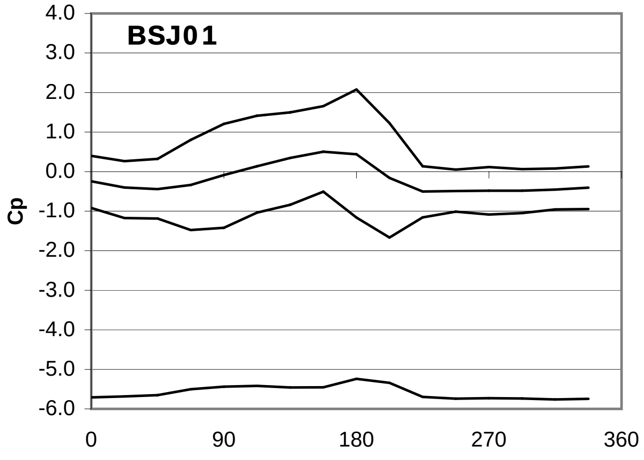
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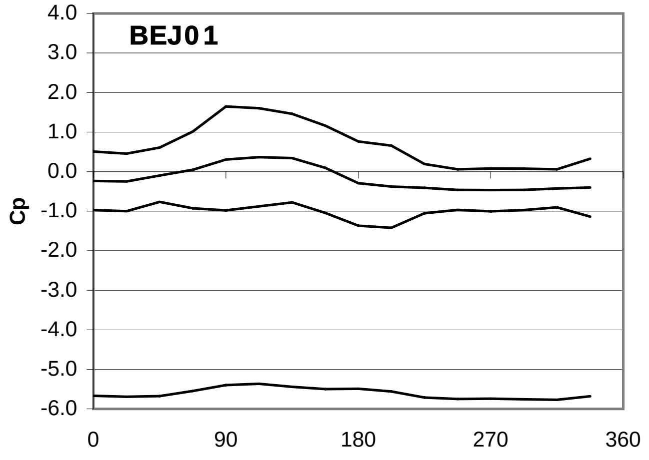
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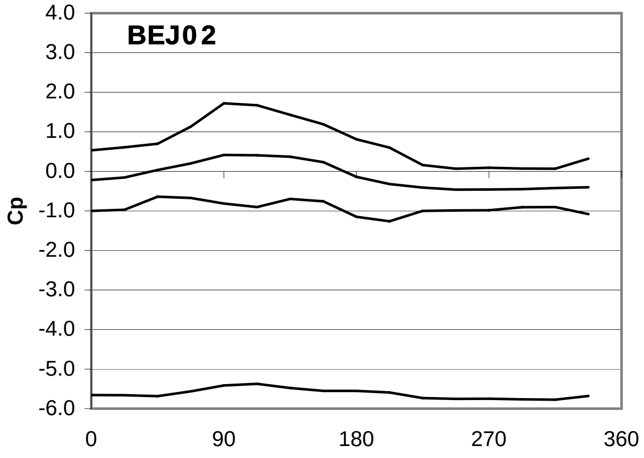
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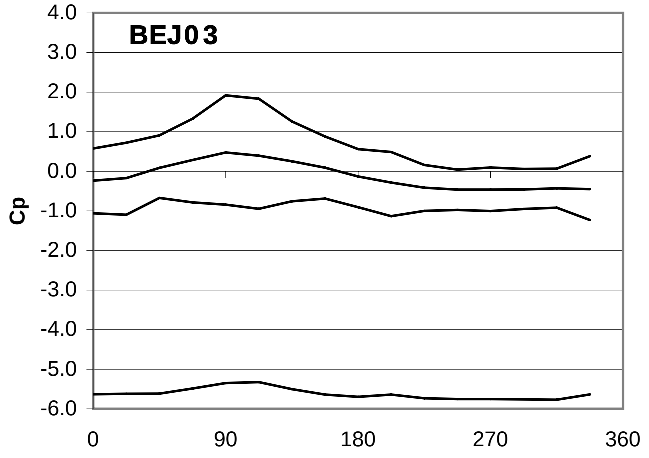
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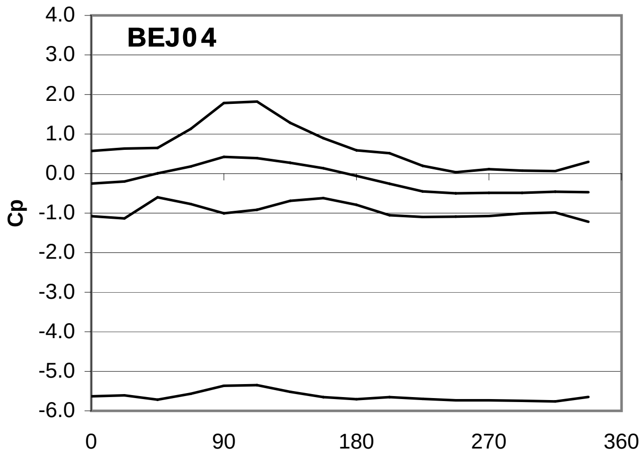
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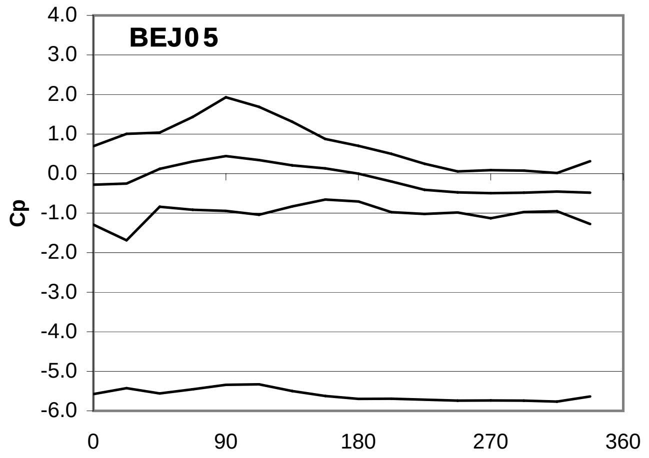
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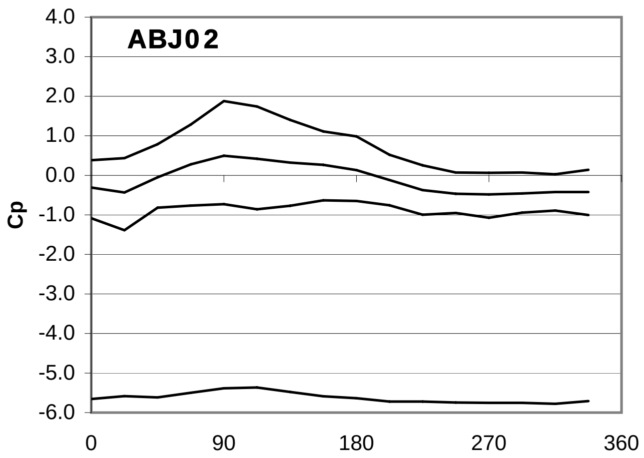
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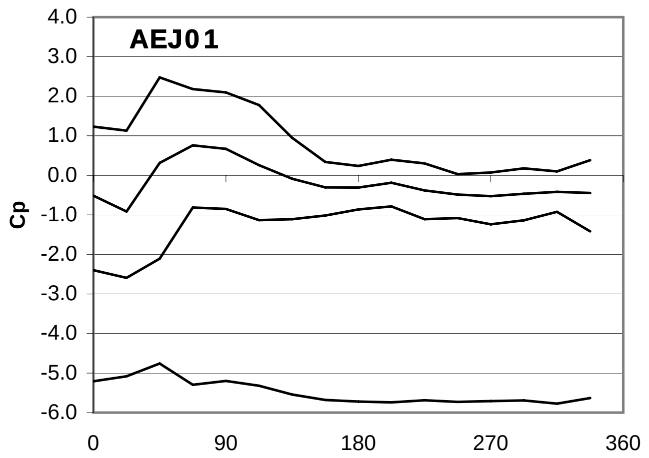
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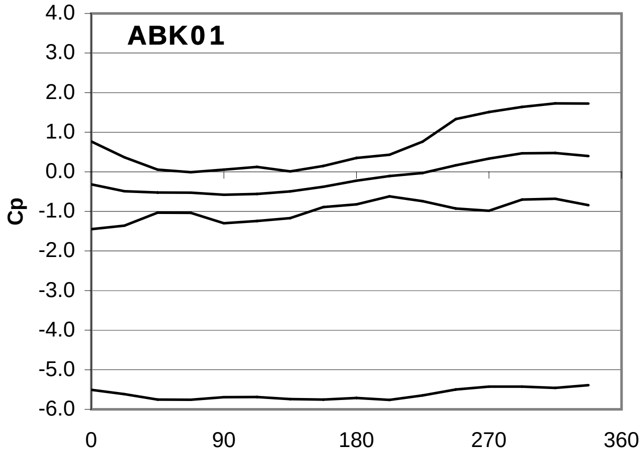
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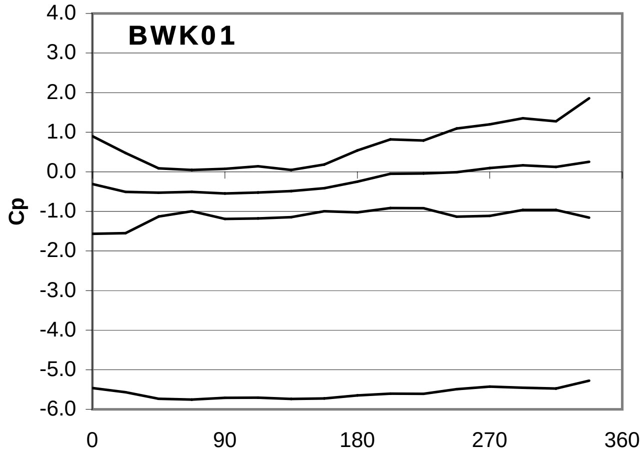
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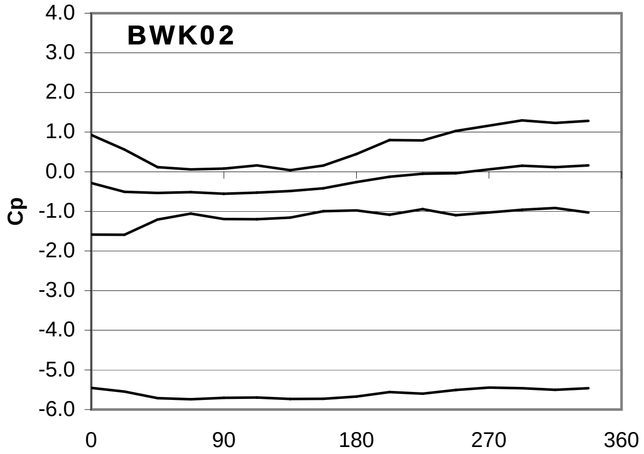
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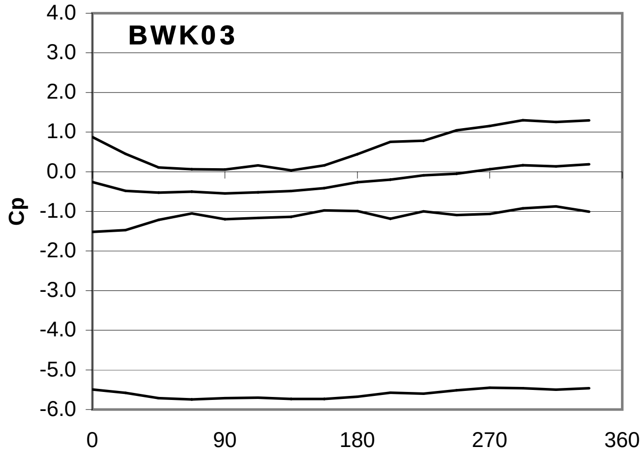
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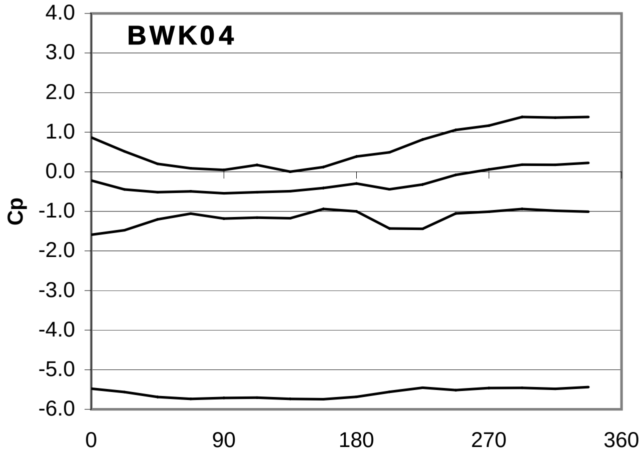
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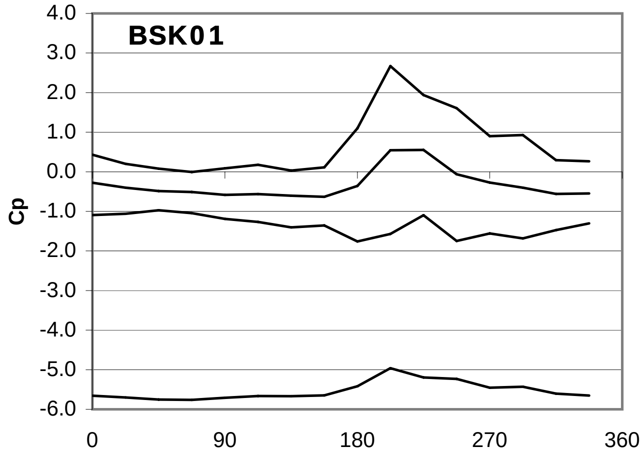
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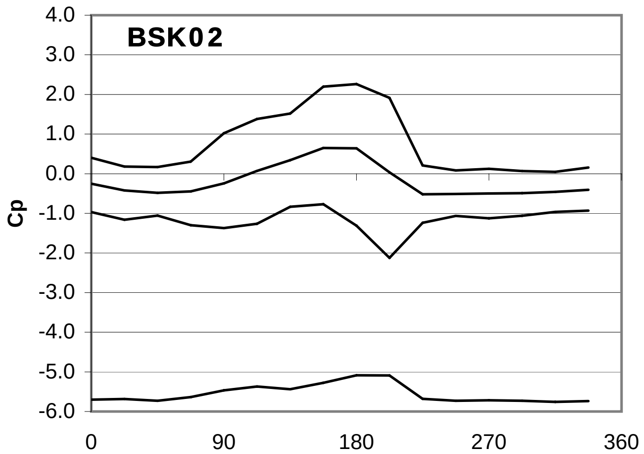
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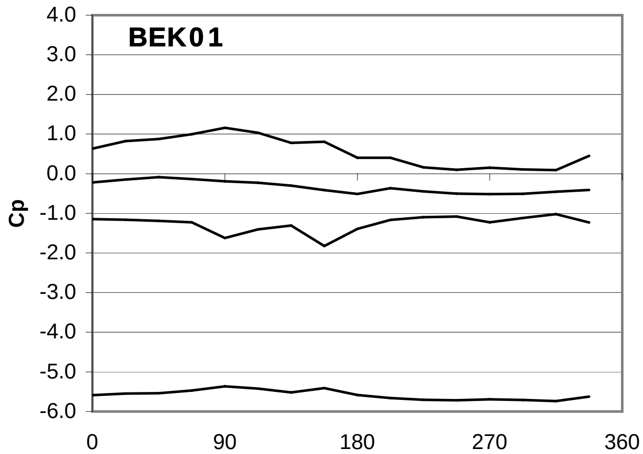
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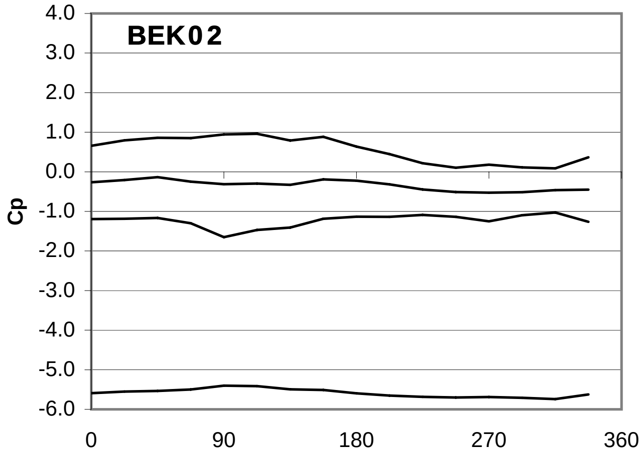
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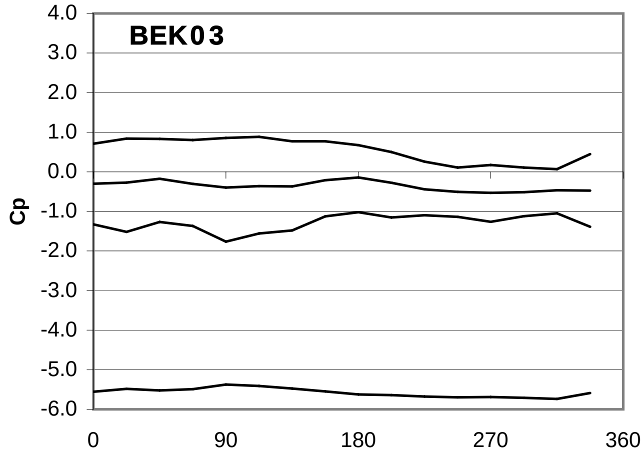
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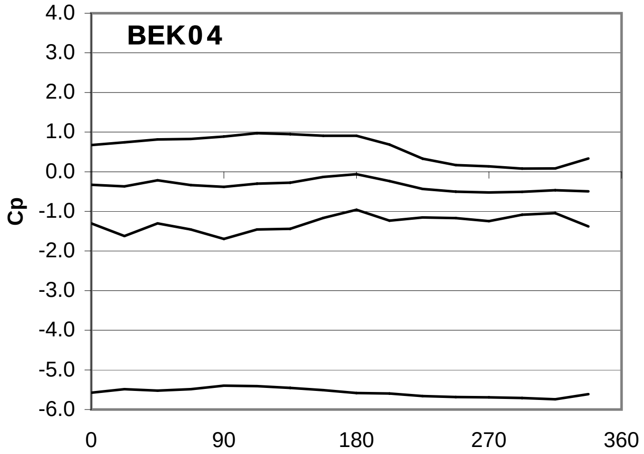
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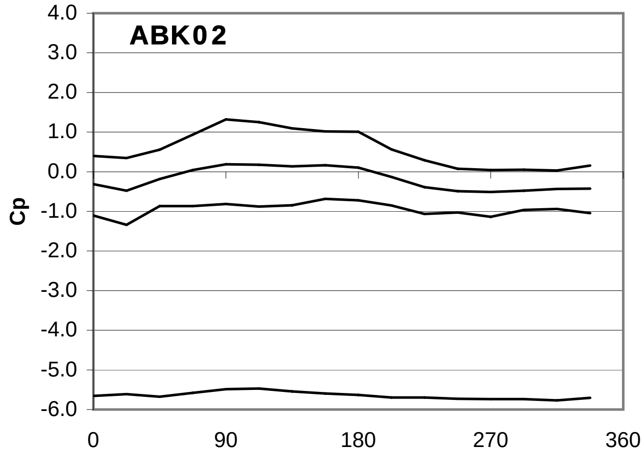
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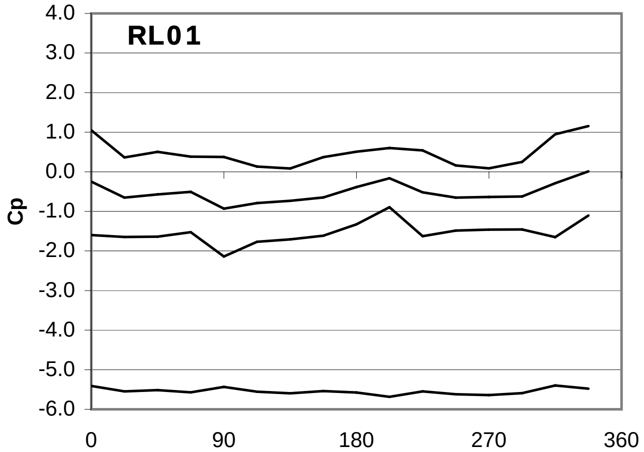
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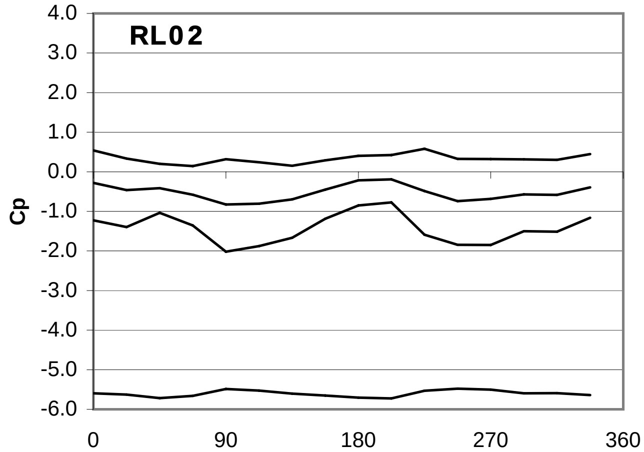
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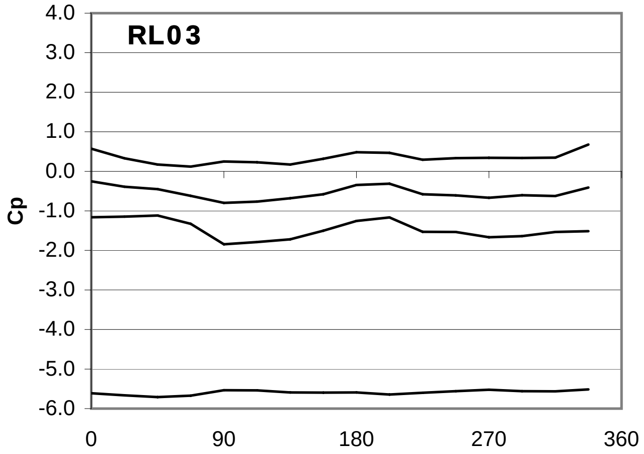
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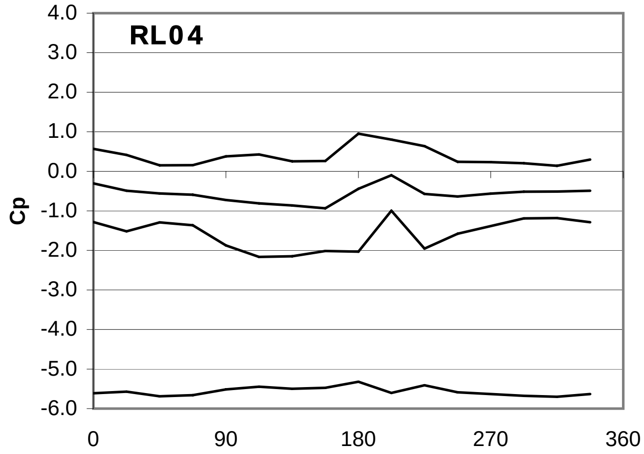
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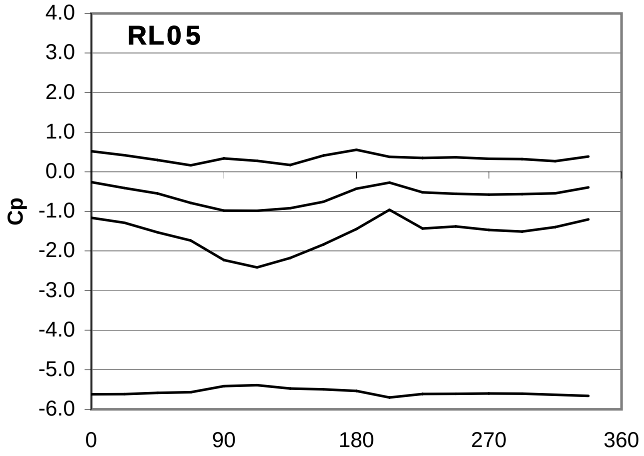
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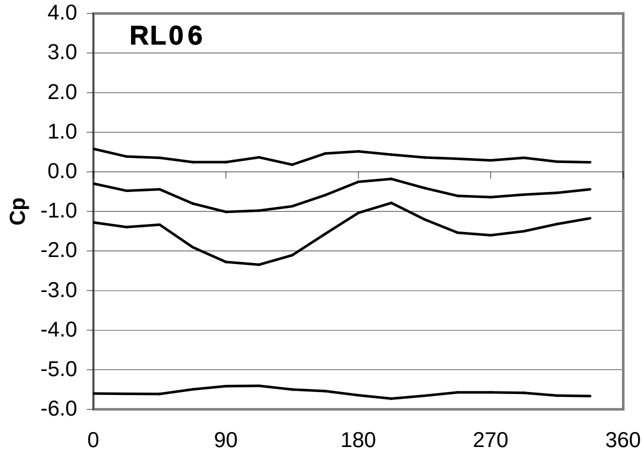
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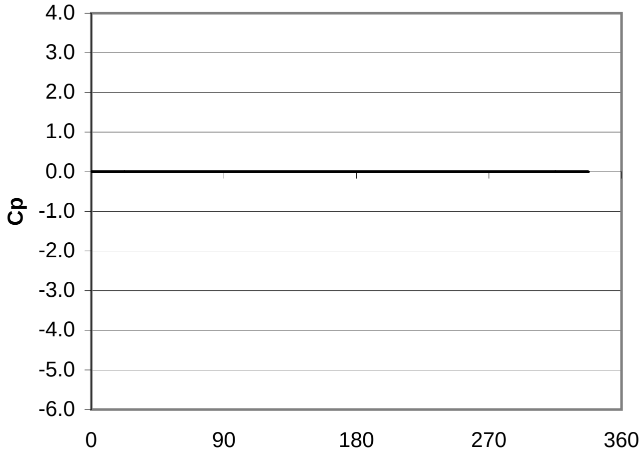

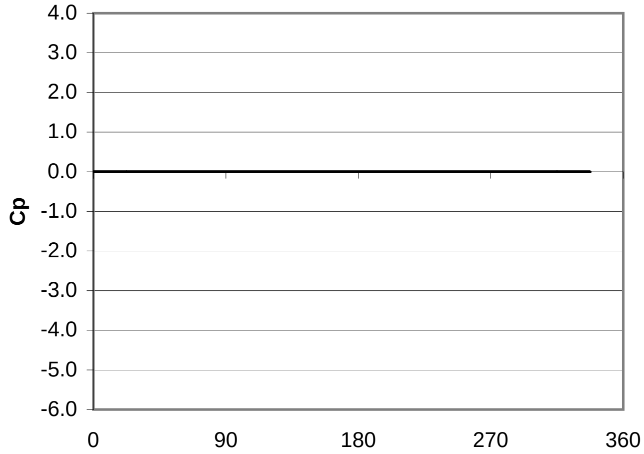

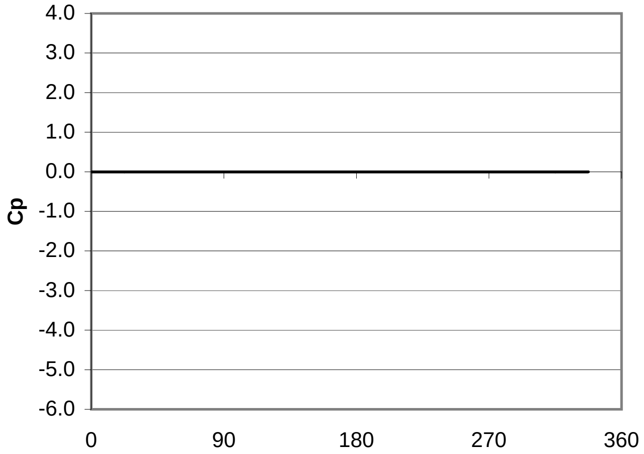

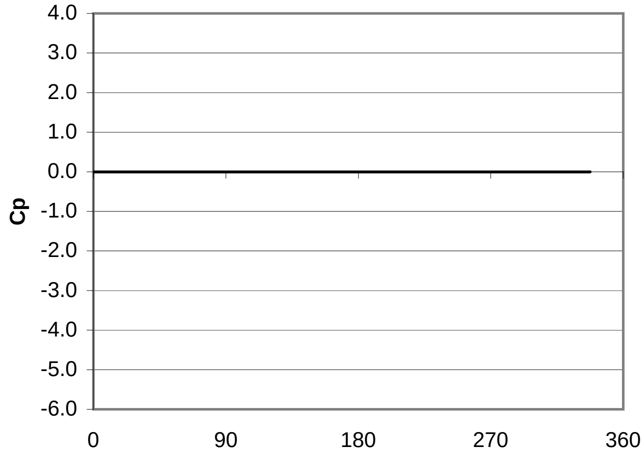

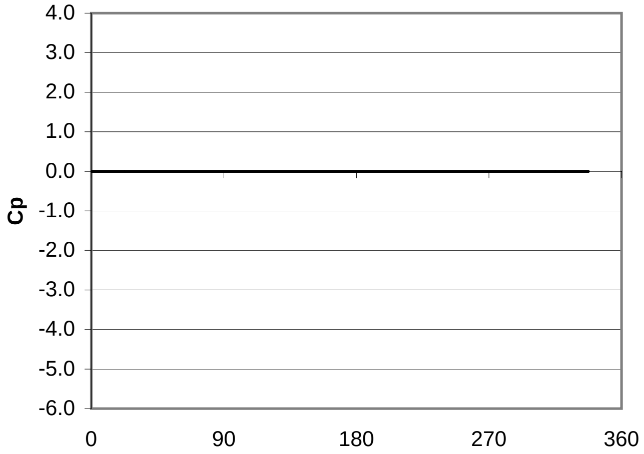

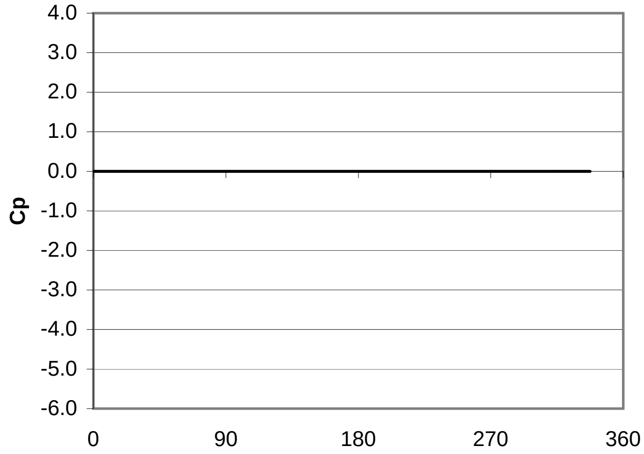

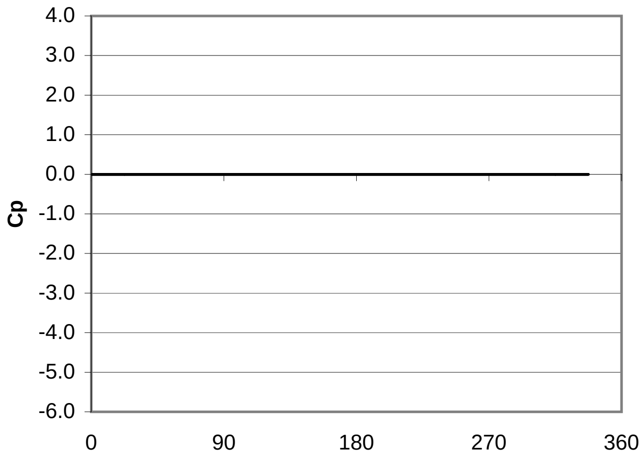
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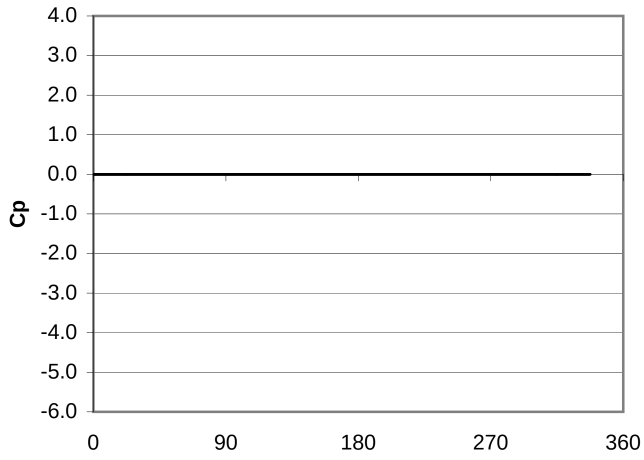
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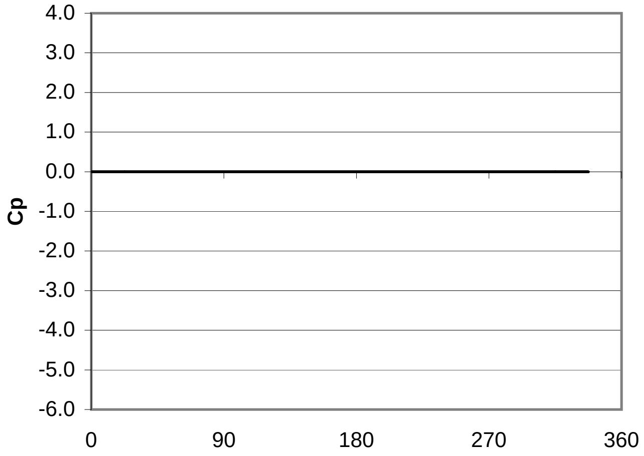
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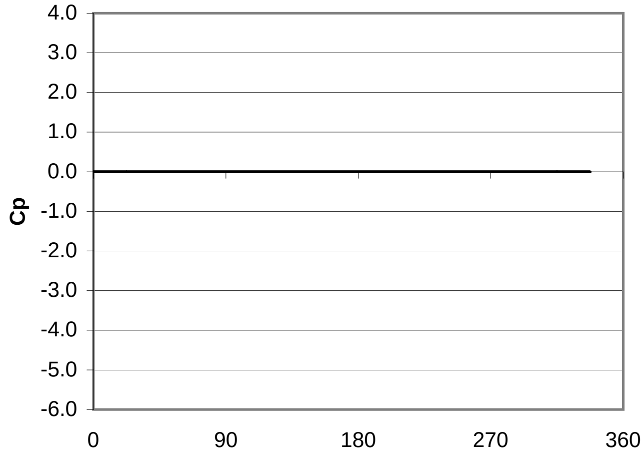
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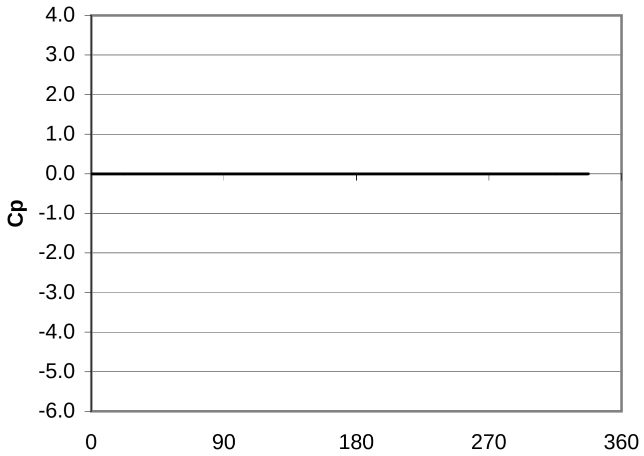
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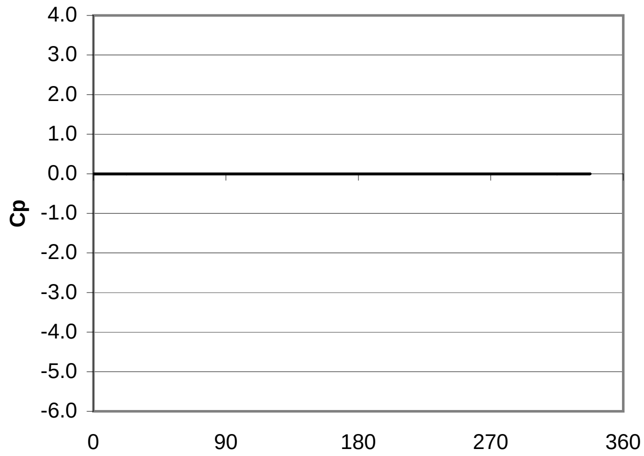
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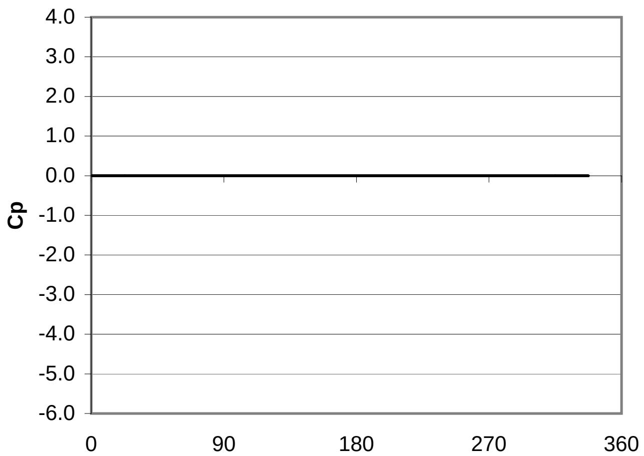
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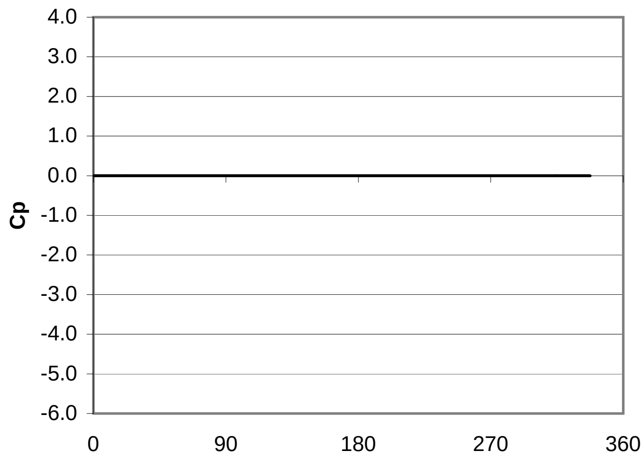
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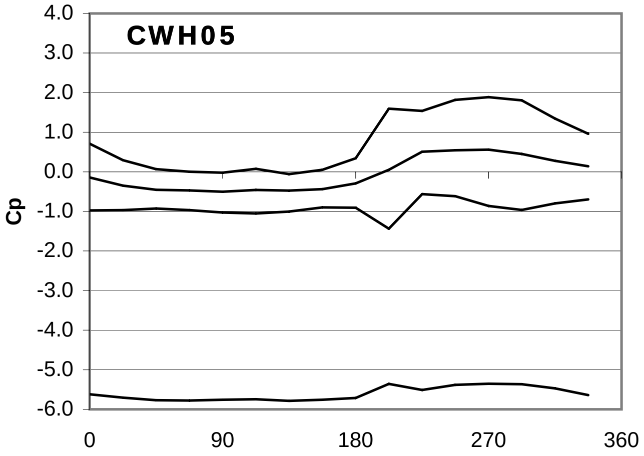

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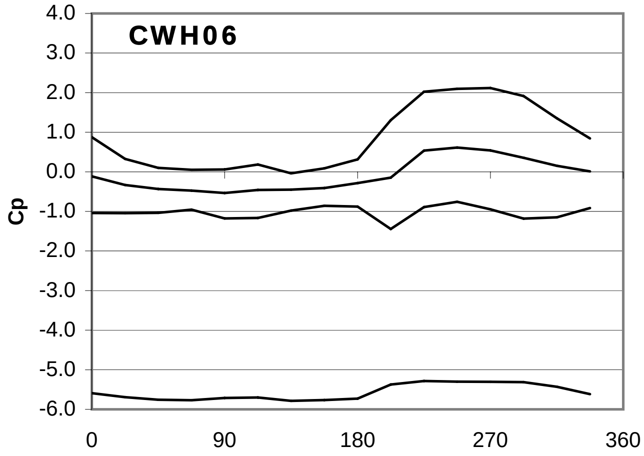

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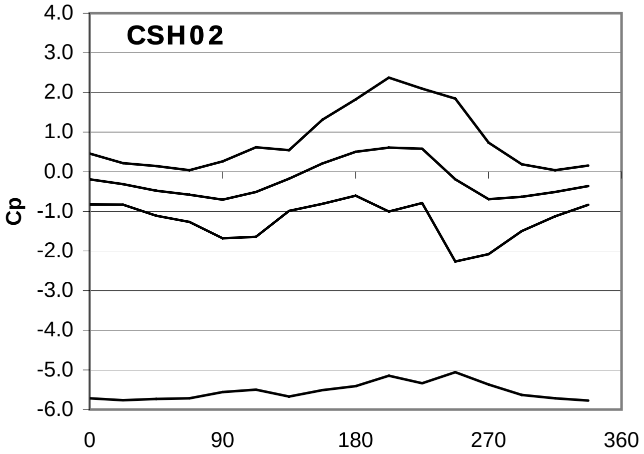

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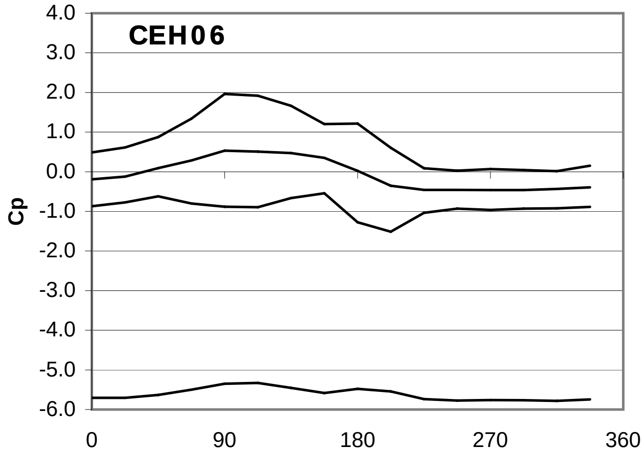

CEH06
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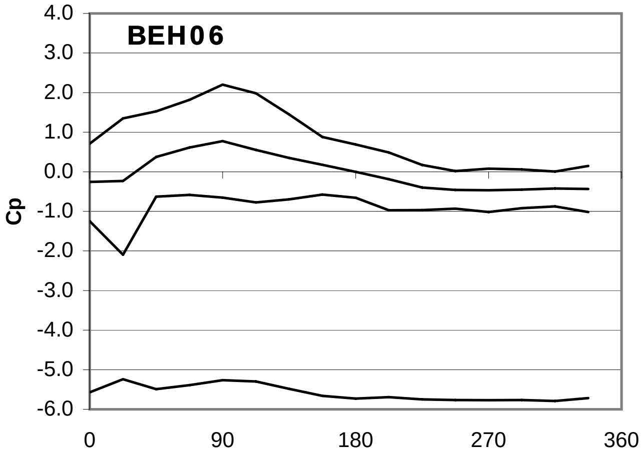

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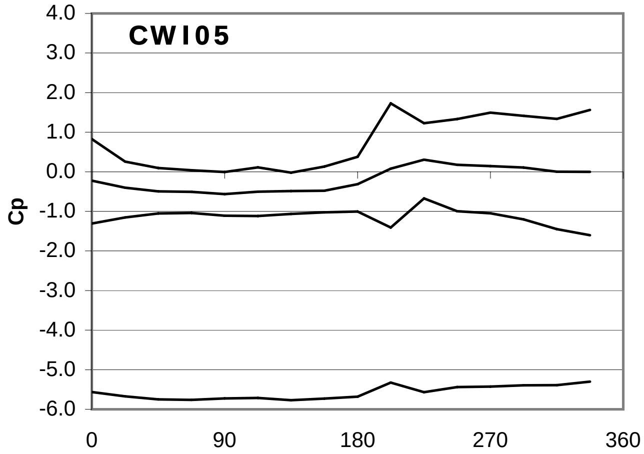

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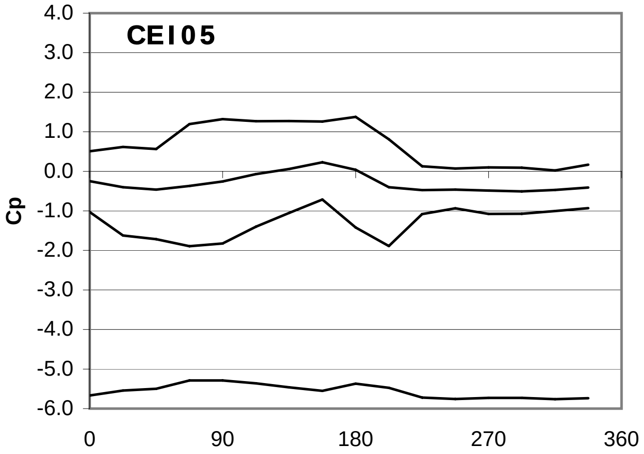

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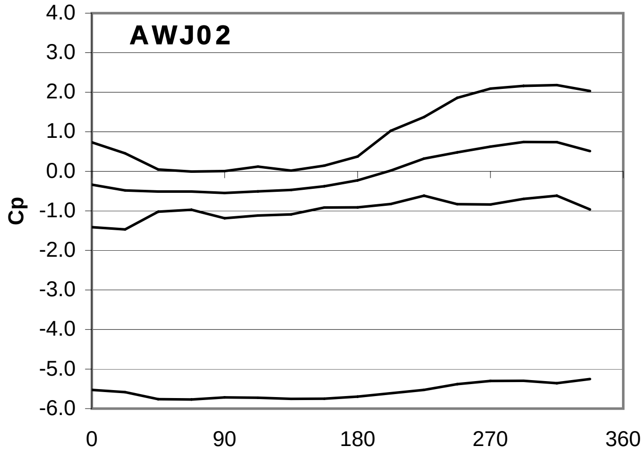

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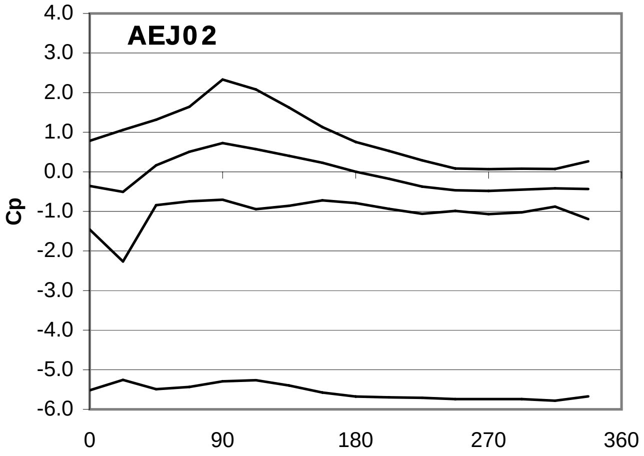
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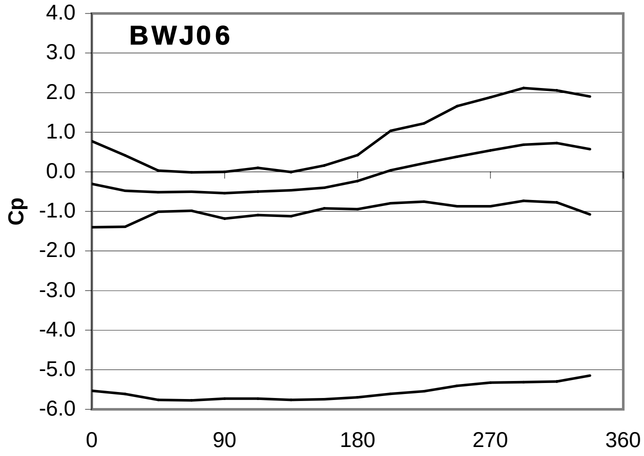
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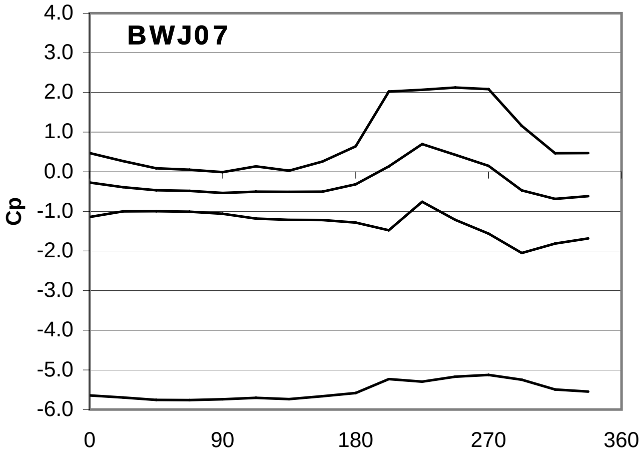
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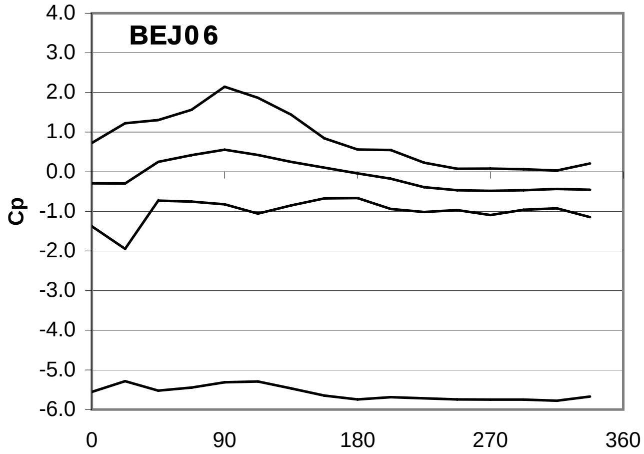
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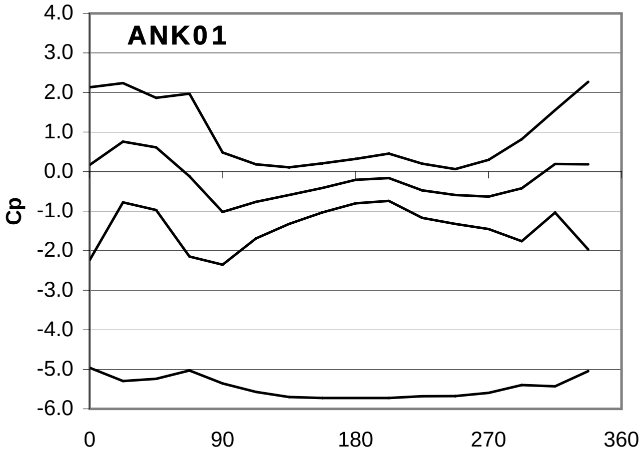
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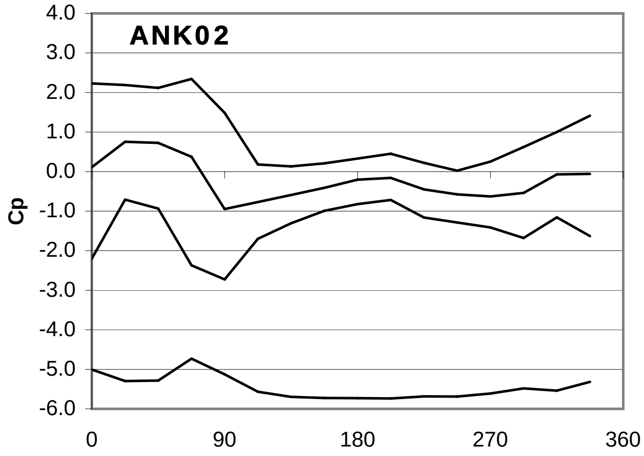
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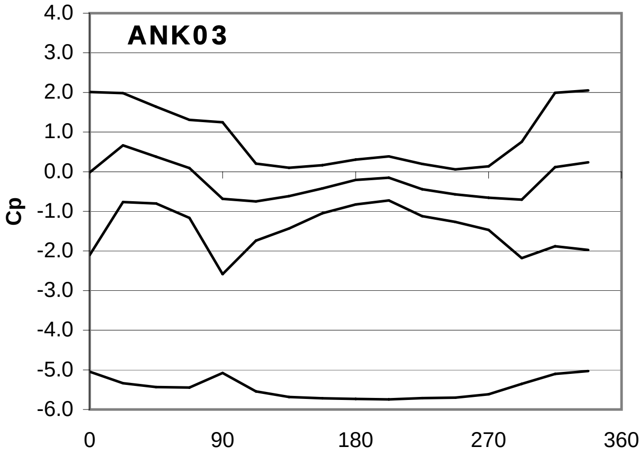
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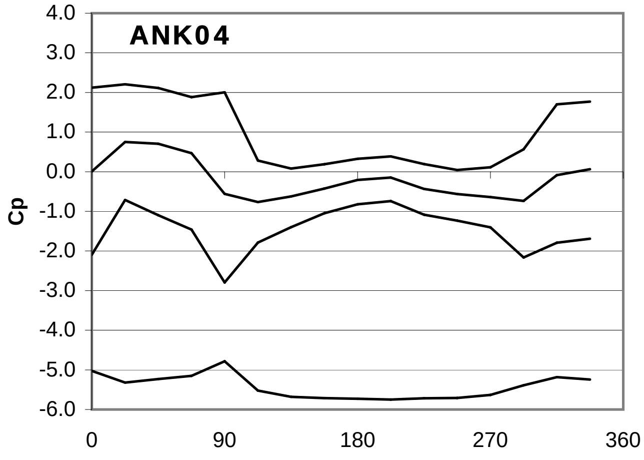
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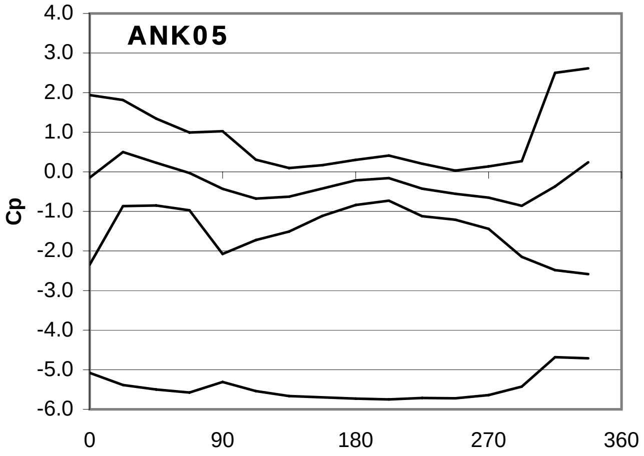
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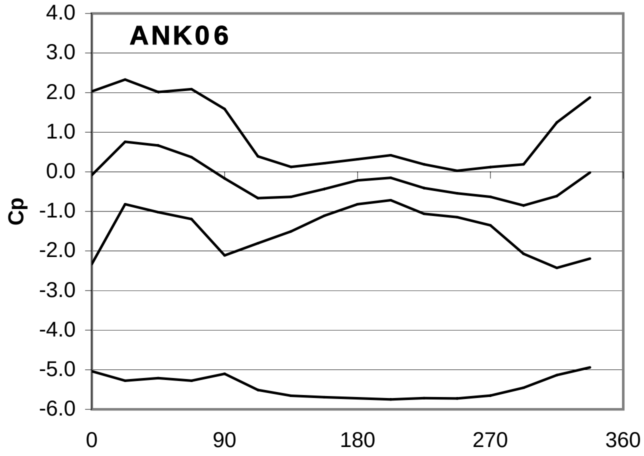
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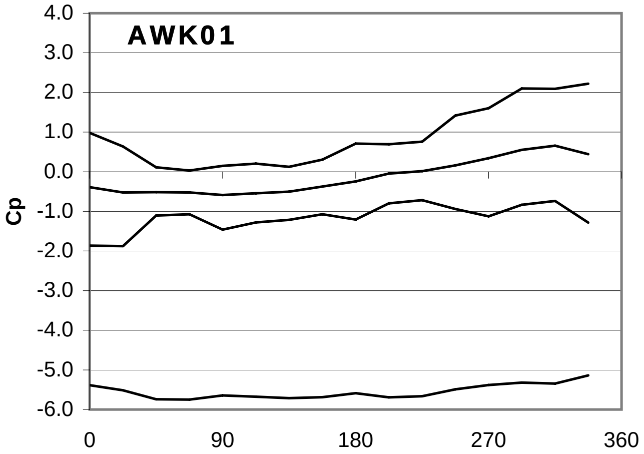
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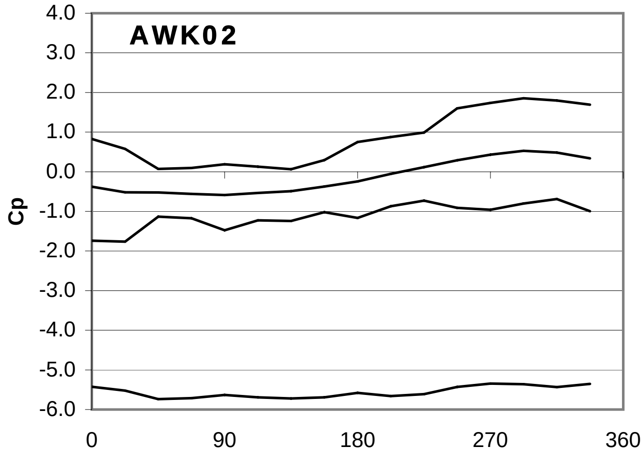
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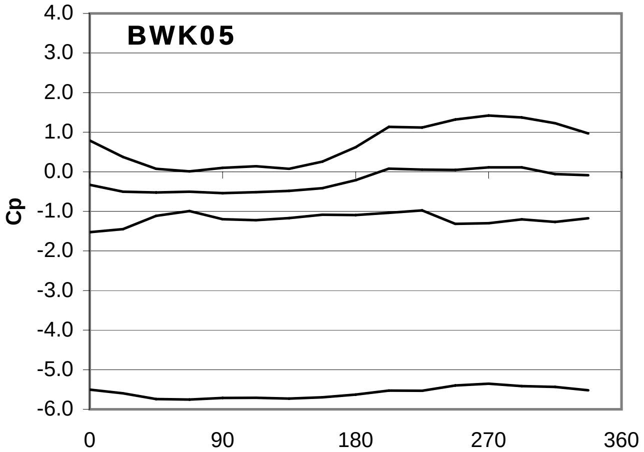
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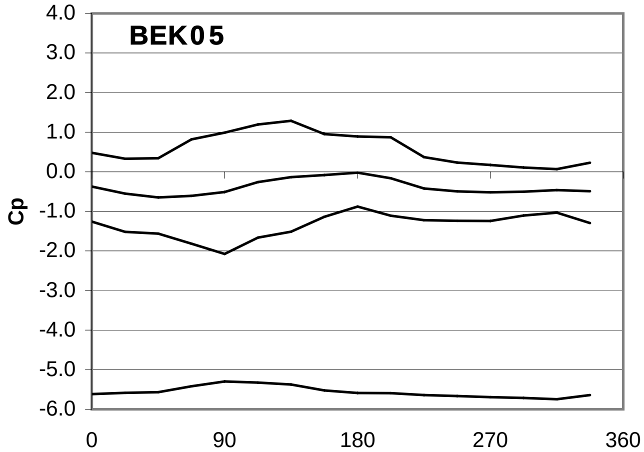
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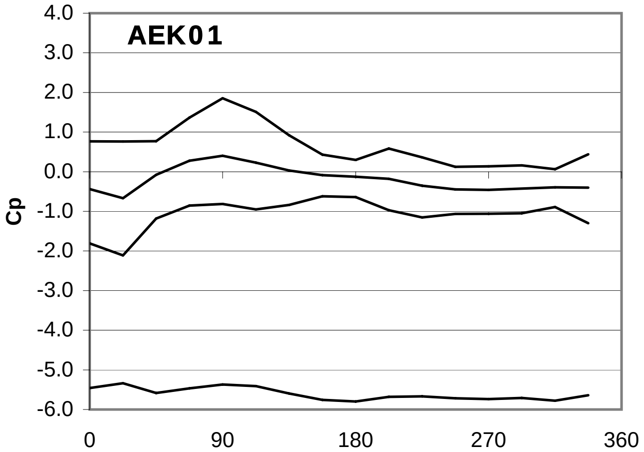
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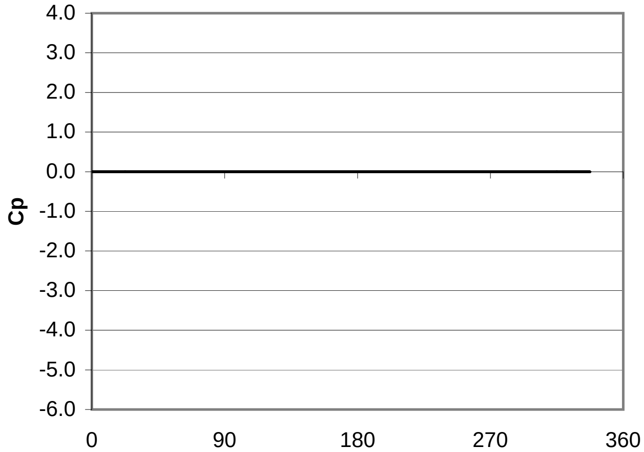
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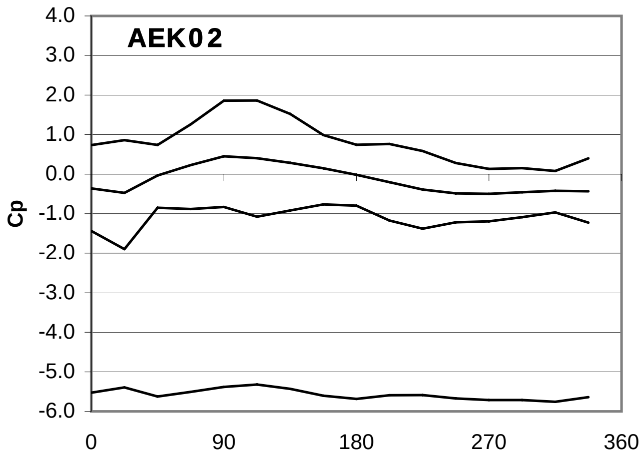
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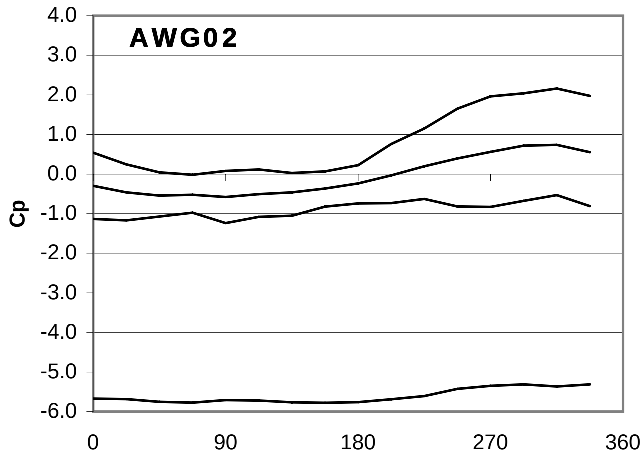
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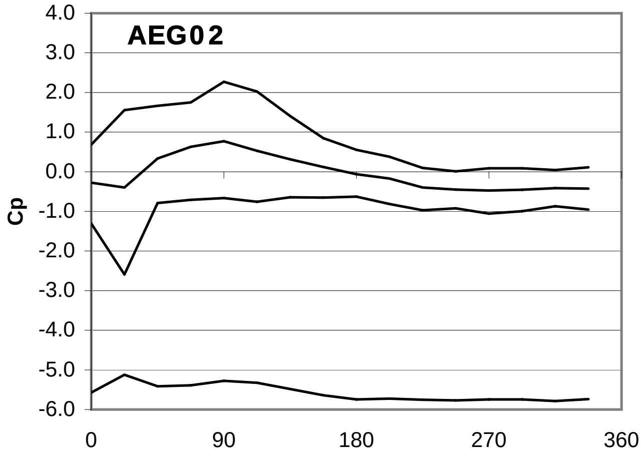
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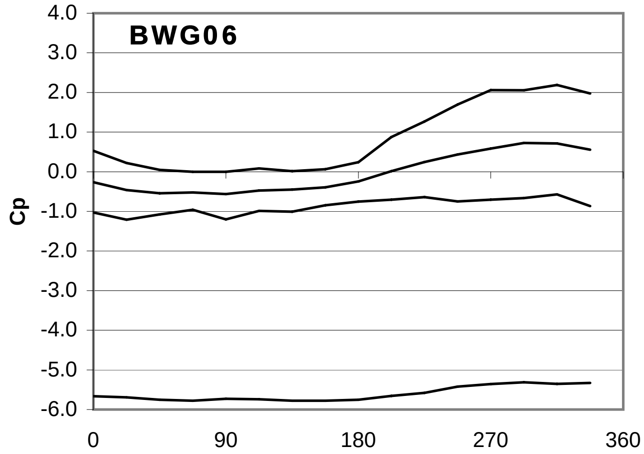
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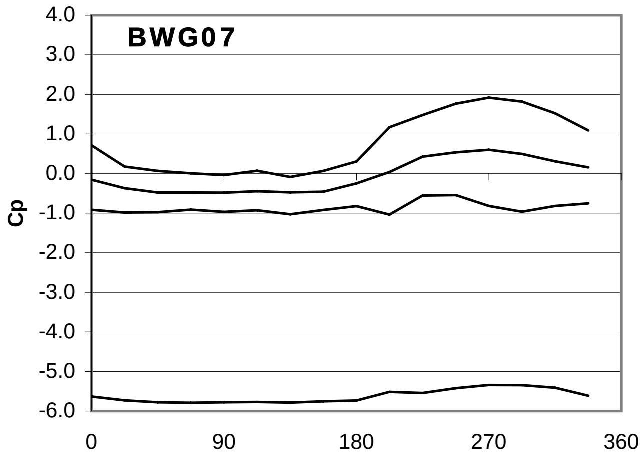
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CWG05
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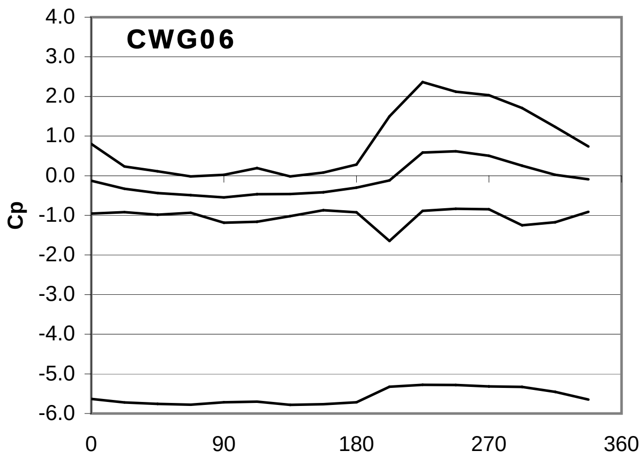
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CSG02
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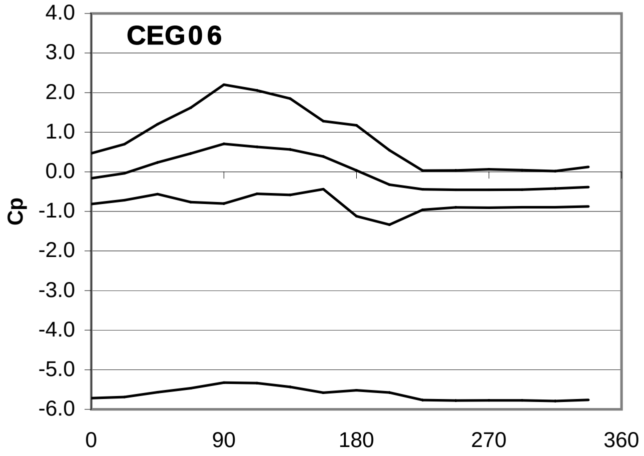
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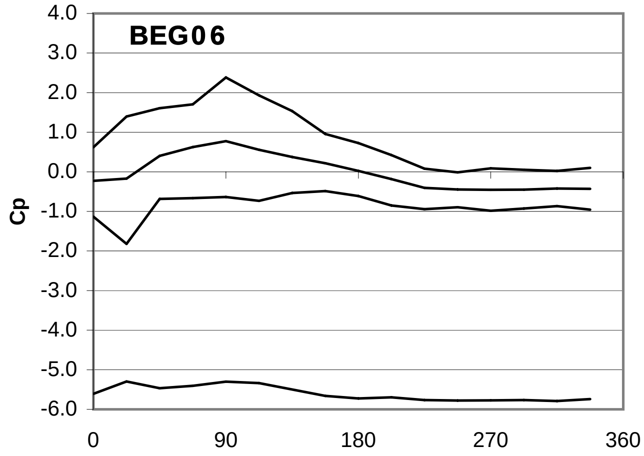
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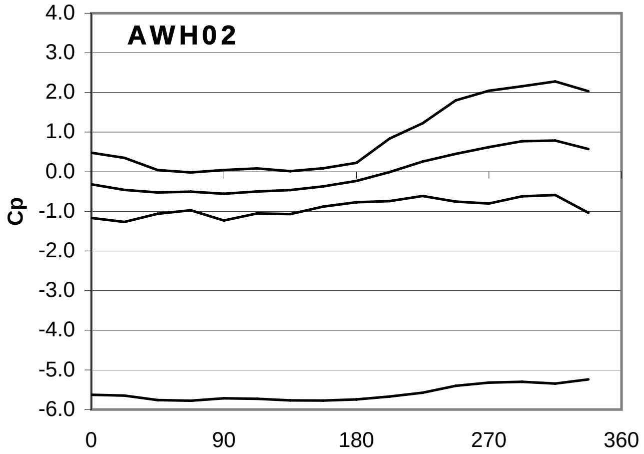
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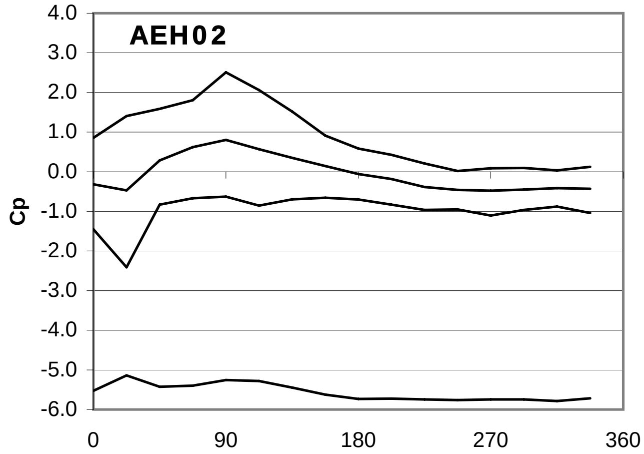
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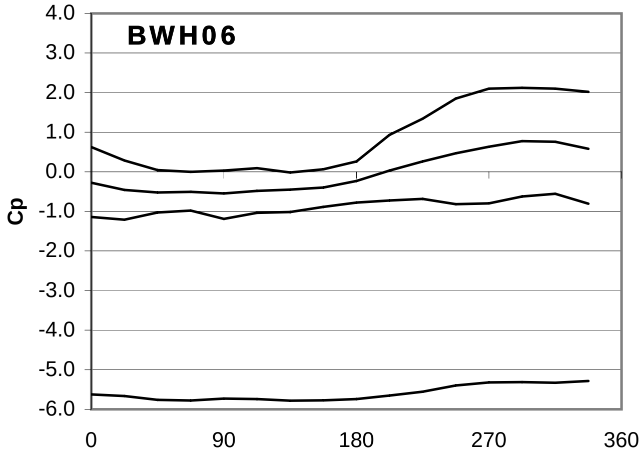
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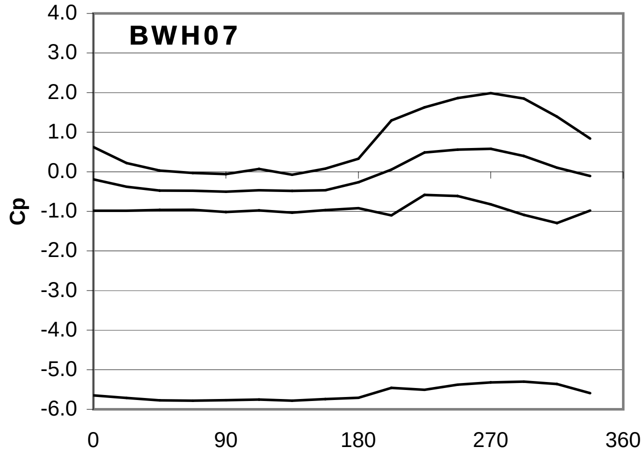
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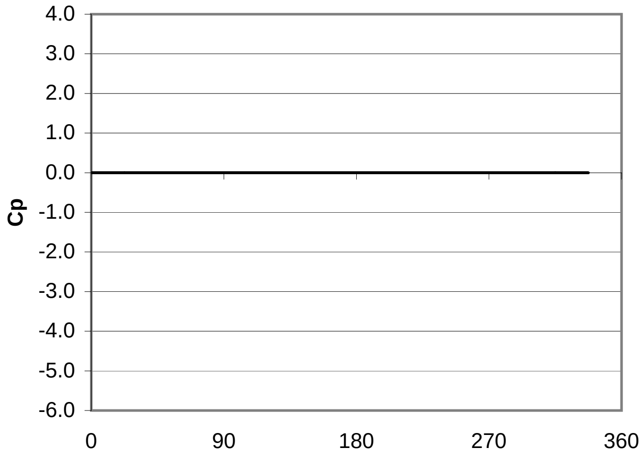
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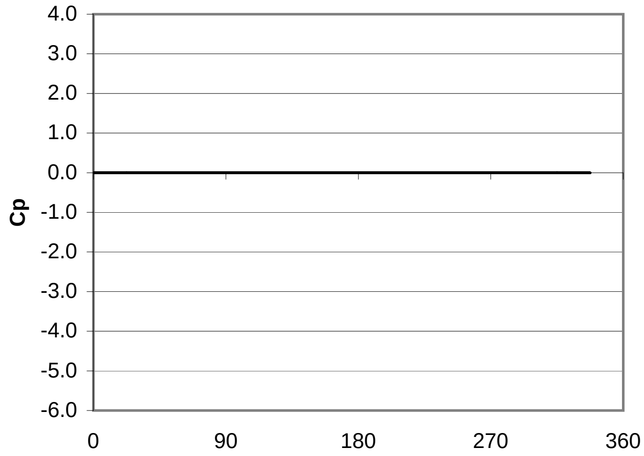
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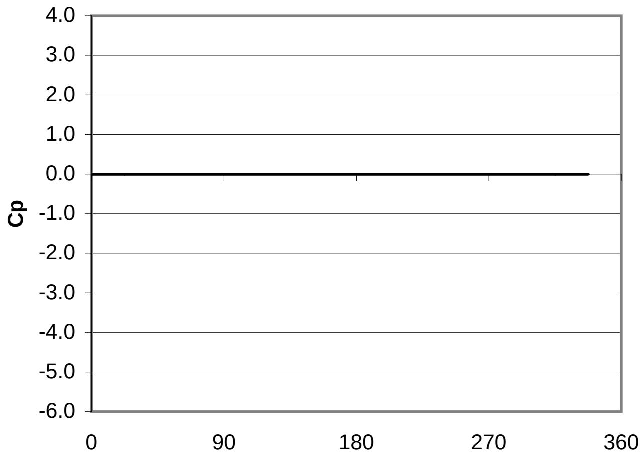
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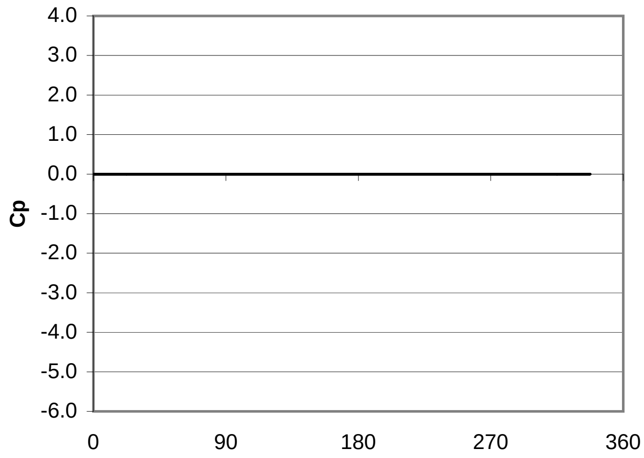
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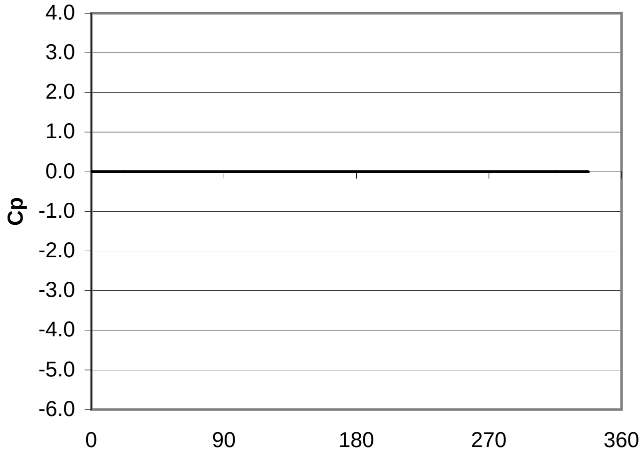
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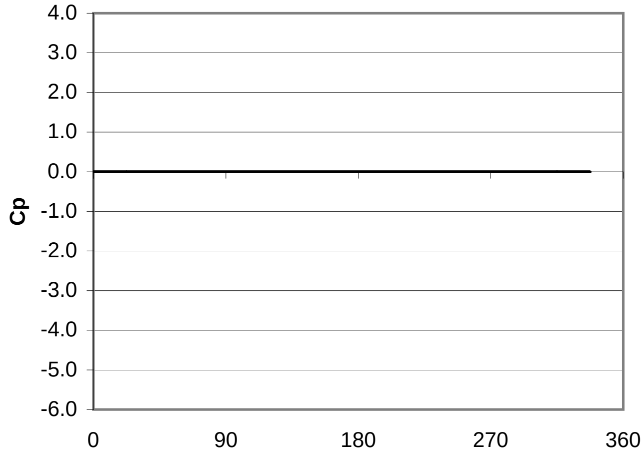
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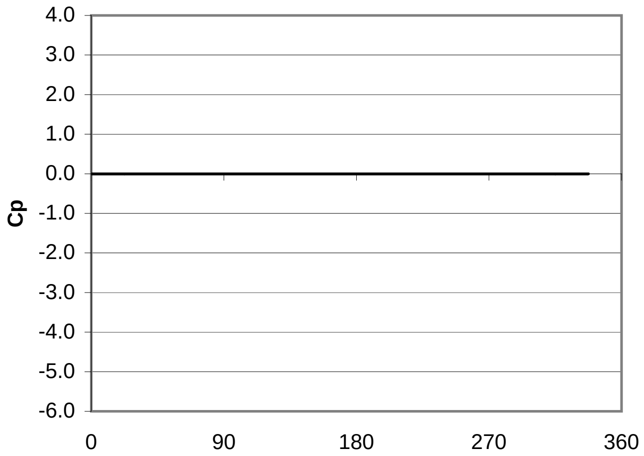
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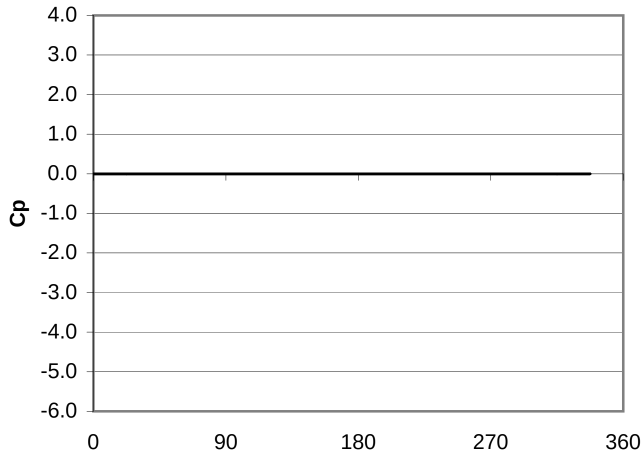
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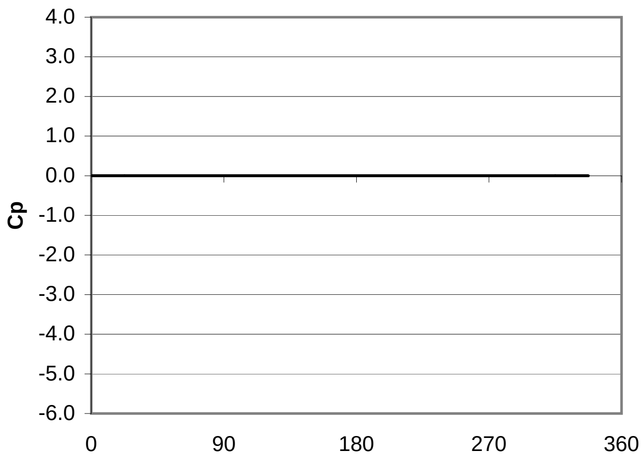
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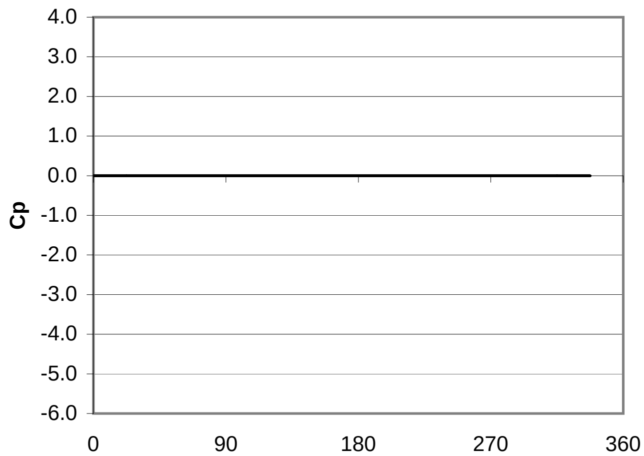
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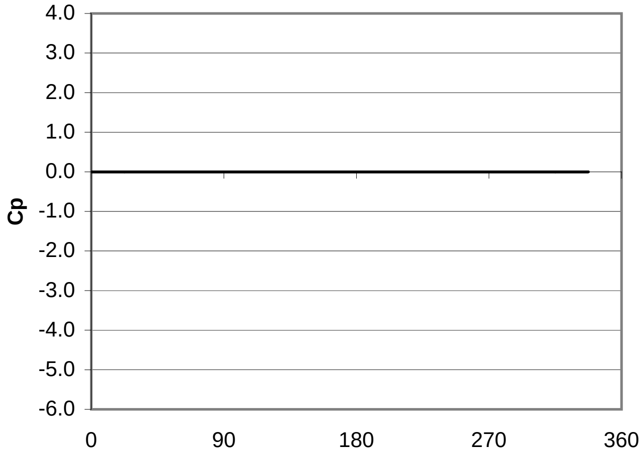
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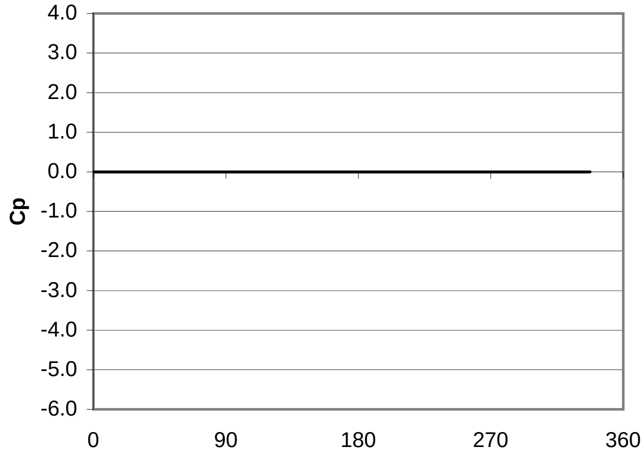
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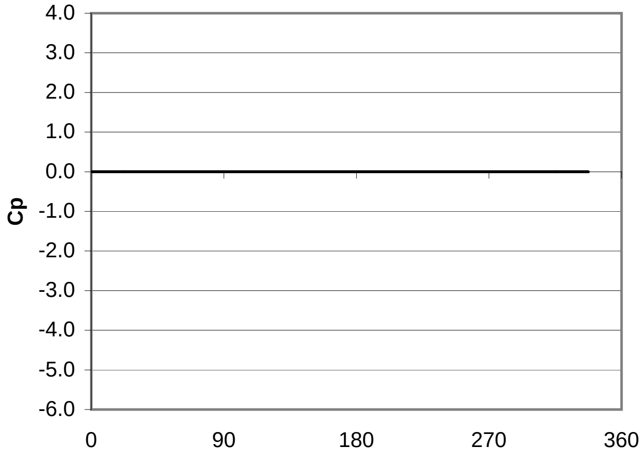
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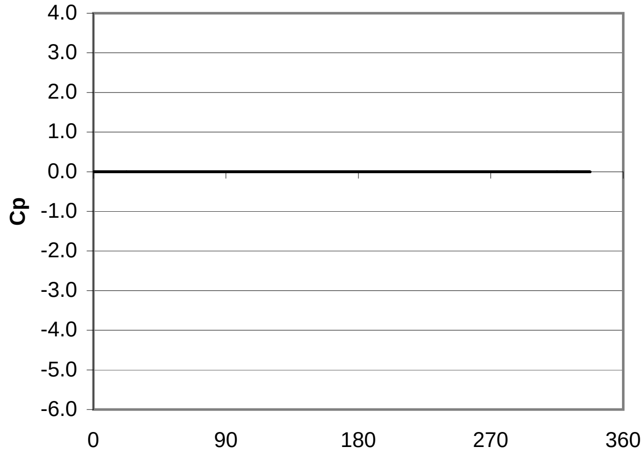
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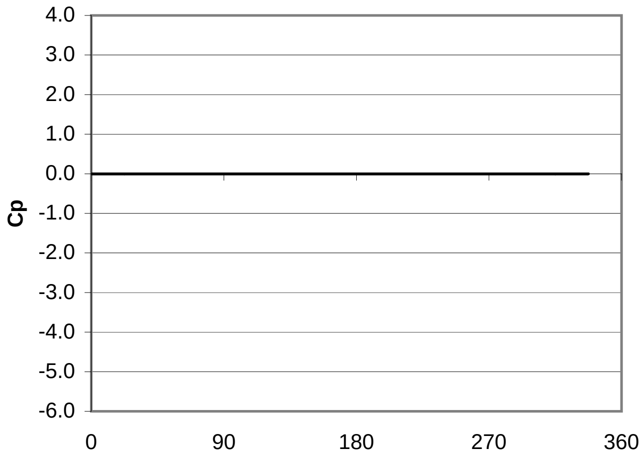
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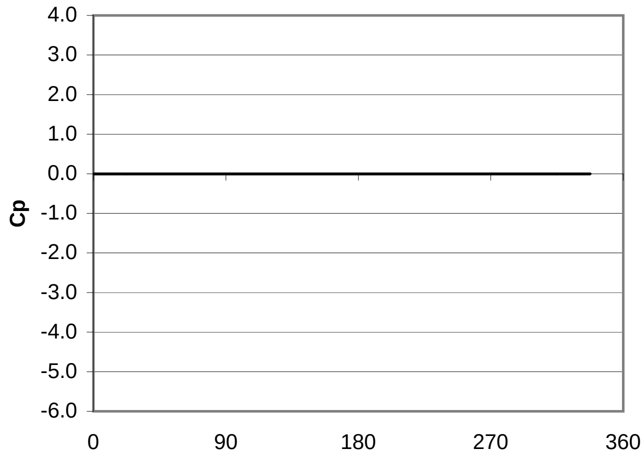
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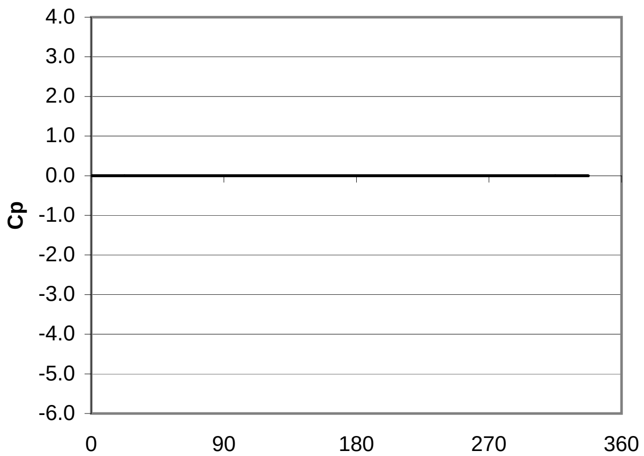
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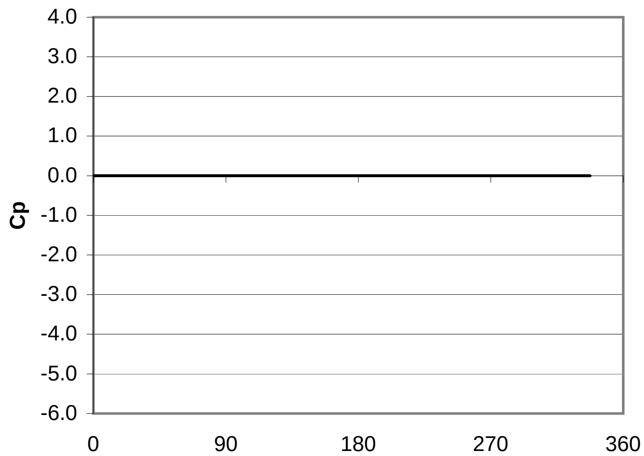
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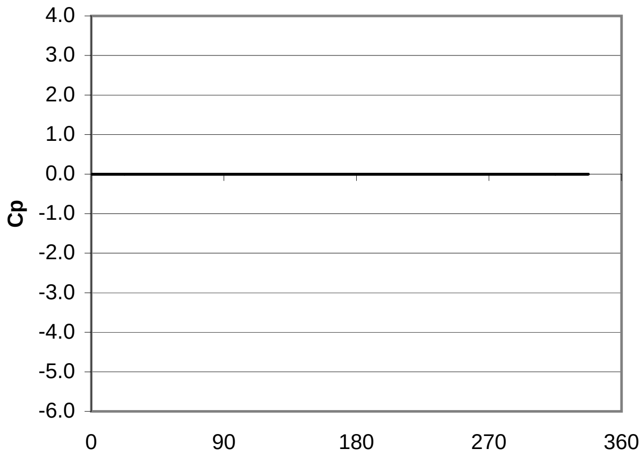
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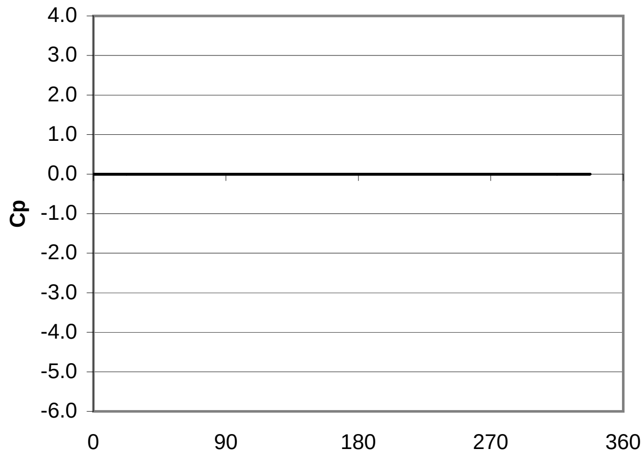
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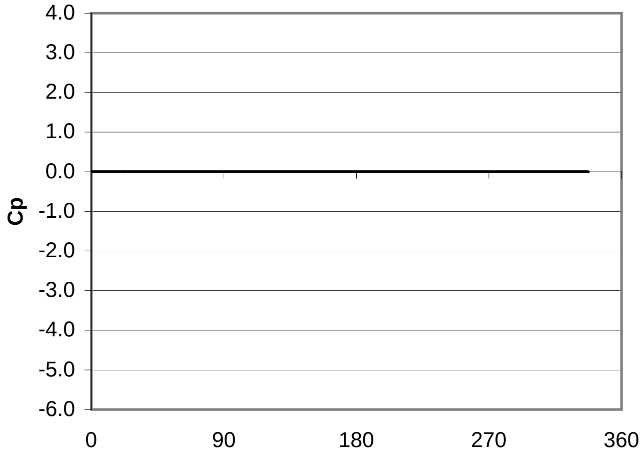
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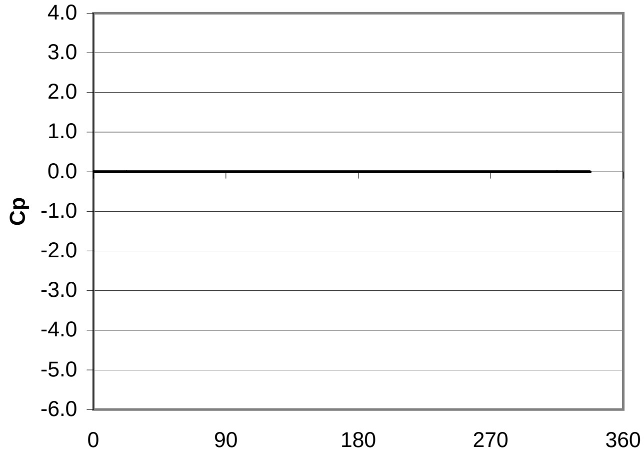
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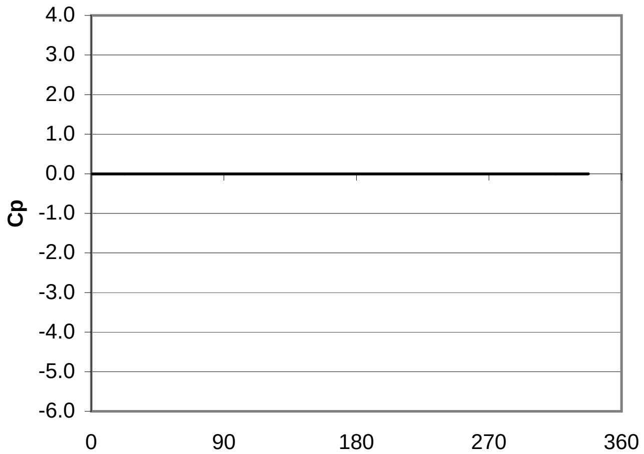
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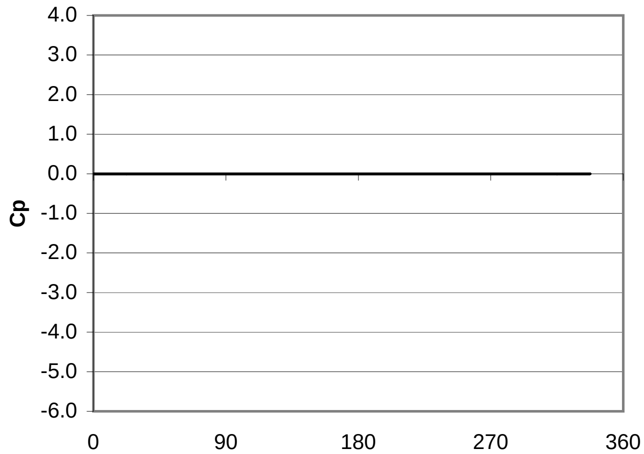
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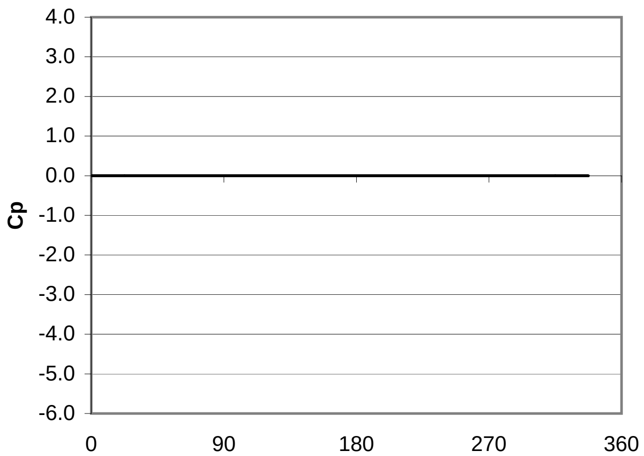
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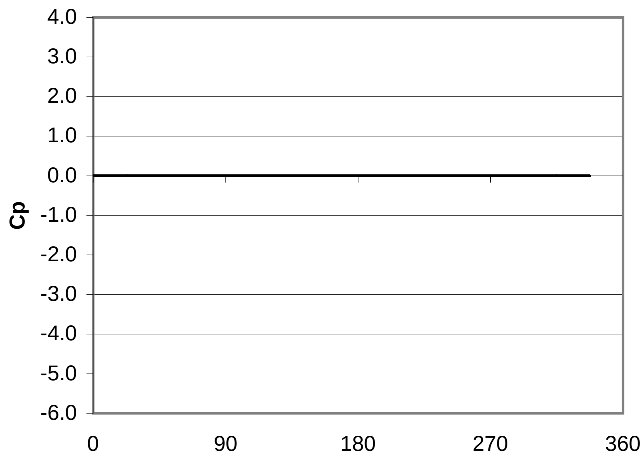
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Appendix B

Unit Opening Parameters

Appendix B1 - Window Opening Sizes

Tap id	Configuration 1		
	Discharge Coefficient	Opening Area (m^2)	Internal Wall Area (m^2)
BWA01	0.66	5.59	14.71
BWA02	0.64	1.54	9.21
BWA03	0.66	5.59	14.71
BWA04	0.64	1.54	9.21
BWA05	0.66	5.59	14.71
CWA01	0.67	4.38	10.55
DNA01	0.68	5.53	11.07
DNA02	0.67	4.68	11.34
DSA01	0.67	4.71	11.34
DSA02	0.64	0.92	11.07
DSA03	0.67	4.71	11.34
DEA01	0.64	0.56	10.86
ANB01	0.65	4.34	15.75
ANB02	0.66	4.29	11.00
ANB03	0.65	3.54	15.26
ANB04	0.66	5.42	15.95
ANB05	0.66	4.29	11.00
ANB06	0.65	4.34	15.75
AWB01	0.64	1.83	12.65
ABB01	0.63	0.60	23.90
BWB01	0.66	5.59	14.71
BWB02	0.64	1.54	9.21
BWB03	0.66	5.59	14.71
BWB04	0.64	1.54	9.21
BWB05	0.66	5.59	14.71
CWB01	0.67	4.38	10.55
DNB01	0.68	5.53	11.07
DNB02	0.67	4.68	11.34
DSB01	0.67	4.71	11.34
DSB02	0.64	0.92	11.07
DSB03	0.67	4.71	11.34
DEB01	0.64	0.56	10.86
CSB01	0.63	0.68	24.61
CEB01	0.65	4.63	16.98
CEB02	0.65	3.38	14.35
CEB03	0.65	4.63	16.98
CEB04	0.65	3.38	14.35
CEB05	0.65	4.63	16.98
BCB01	0.63	0.60	23.90
BEB01	0.65	4.63	16.98
BEB02	0.65	3.38	14.35
BEB03	0.65	4.63	16.98
BEB04	0.65	3.38	14.35
BEB05	0.65	4.63	16.98
ABB02	0.63	0.60	23.90
AEB01	0.64	1.83	12.65
ANC01	0.65	4.34	15.75

Appendix B1 - Window Opening Sizes

Tap id	Configuration 1		
	Discharge Coefficient	Opening Area (m^2)	Internal Wall Area (m^2)
ANC02	0.66	4.29	11.00
ANC03	0.65	3.54	15.26
ANC04	0.66	5.42	15.95
ANC05	0.66	4.29	11.00
ANC06	0.65	4.34	15.75
AWC01	0.64	1.83	12.65
ABC01	0.63	0.60	23.90
BWC01	0.66	5.59	14.71
BWC02	0.64	1.54	9.21
BWC03	0.66	5.59	14.71
BWC04	0.64	1.54	9.21
BWC05	0.66	5.59	14.71
CWC01	0.67	4.38	10.55
CEB06	0.65	3.38	14.35
DNC01	0.68	5.53	11.07
DNC02	0.67	4.68	11.34
DSC01	0.67	4.71	11.34
DSC02	0.64	0.92	11.07
DSC03	0.67	4.71	11.34
DEC01	0.64	0.56	10.86
CSC01	0.63	0.68	24.61
CEC01	0.65	4.63	16.98
CEC02	0.65	3.38	14.35
CEC03	0.65	4.63	16.98
CEC04	0.65	3.38	14.35
CEC05	0.65	4.63	16.98
BCC01	0.63	0.60	23.90
BEC01	0.65	4.63	16.98
BEC02	0.65	3.38	14.35
BEC03	0.65	4.63	16.98
BEC04	0.65	3.38	14.35
BEC05	0.65	4.63	16.98
ABC02	0.64	1.20	23.90
AEC01	0.64	1.83	12.65
DND01	0.65	2.65	8.94
DND02	0.65	2.65	8.94
DSD01	0.64	1.36	17.88
DSD02	0.64	1.36	17.88
DSD03	0.67	4.71	11.34
DED01	0.64	0.56	10.86
CSD01	0.63	0.68	24.61
ANF01	0.65	4.34	15.75
ANF02	0.66	4.29	11.00
ANF03	0.65	3.54	15.26
ANF04	0.66	5.42	15.95
ANF05	0.66	4.29	11.00
ANF06	0.65	4.34	15.75

Appendix B1 - Window Opening Sizes

Tap id	Configuration 1		
	Discharge Coefficient	Opening Area (m^2)	Internal Wall Area (m^2)
AWF01	0.64	1.83	12.65
ABF01	0.63	0.60	23.90
BWF01	0.66	5.59	14.71
BWF02	0.64	1.54	9.21
BWF03	0.66	5.59	14.71
BWF04	0.64	1.54	9.21
BWF05	0.66	5.59	14.71
CWF01	0.67	4.38	10.55
CWF02	0.67	4.38	10.55
CWF03	0.68	3.61	7.22
CWF04	0.68	3.61	7.22
CSF01	0.63	0.68	24.61
CEF01	0.65	4.63	16.98
CEF02	0.65	3.38	14.35
CEF03	0.65	4.63	16.98
CEF04	0.65	3.38	14.35
CEF05	0.65	4.63	16.98
BCF01	0.63	0.60	23.90
BEF01	0.65	4.63	16.98
BEF02	0.65	3.38	14.35
BEF03	0.65	4.63	16.98
BEF04	0.65	3.38	14.35
BEF05	0.65	4.63	16.98
ABF02	0.63	0.60	23.90
AEF01	0.64	1.83	12.65
BWA06	0.64	1.54	9.21
CWA02	0.68	3.61	7.22
CWA03	0.68	3.61	7.22
CWA04	0.68	4.37	8.73
DNA03	0.68	7.27	15.10
DSA04	0.64	0.92	11.07
DSA05	0.67	4.71	11.34
DSA06	0.64	0.92	11.07
AWB02	0.64	0.85	8.25
AEB02	0.64	0.85	8.25
BWB06	0.64	1.54	9.21
BWB07	0.68	3.61	7.22
CWB02	0.68	3.61	7.22
CWB03	0.68	4.37	8.73
DNB03	0.68	7.27	15.10
DSB04	0.64	0.92	11.07
DSB05	0.67	4.71	11.34
DSB06	0.64	0.92	11.07
BEB06	0.65	3.38	14.35
AWC02	0.64	0.85	8.25
AEC02	0.64	0.85	8.25
BWC06	0.64	1.54	9.21

Appendix B1 - Window Opening Sizes

Tap id	Configuration 1		
	Discharge Coefficient	Opening Area (m^2)	Internal Wall Area (m^2)
BWC07	0.68	3.61	7.22
CWC02	0.68	3.61	7.22
CWC03	0.68	4.37	8.73
DNC03	0.68	7.27	15.10
DSC04	0.64	0.92	11.07
DSC05	0.67	4.71	11.34
DSC06	0.64	0.92	11.07
CEC06	0.65	3.38	14.35
BEC06	0.65	3.38	14.35
DND03	0.68	7.27	15.10
DSD05	0.67	4.71	11.34
DSD06	0.64	0.92	11.07
AWF02	0.64	0.85	8.25
AEF02	0.64	0.85	8.25
BWF06	0.64	1.54	9.21
BWF07	0.68	3.61	7.22
CWE01	0.68	3.61	7.22
CWE02	0.70	8.02	14.44
CSE01	0.63	0.68	26.13
CEF06	0.65	3.38	14.35
BEF06	0.65	3.38	14.35
CWF05	0.68	3.61	7.22
CWF06	0.67	4.38	10.55
CSF02	0.63	0.69	23.44
DSD04	0.64	1.36	17.88
ANG02	0.66	4.29	11.00
ANG03	0.65	3.54	15.26
ANG04	0.66	5.42	15.95
ANG05	0.66	4.29	11.00
ANG06	0.65	4.34	15.75
AWG01	0.64	1.83	12.65
ABG01	0.63	0.60	23.90
BWG01	0.66	5.59	14.71
BWG02	0.64	1.54	9.21
BWG03	0.66	5.59	14.71
BWG04	0.64	1.54	9.21
BWG05	0.66	5.59	14.71
CWG01	0.67	4.38	10.55
CWG02	0.67	4.38	10.55
CWG03	0.68	3.61	7.22
CWG04	0.68	3.61	7.22
CSG01	0.63	0.68	24.61
CEG01	0.65	4.63	16.98
CEG02	0.65	3.38	14.35
CEG03	0.65	4.63	16.98
CEG04	0.65	3.38	14.35
CEG05	0.65	4.63	16.98

Appendix B1 - Window Opening Sizes

Tap id	Configuration 1		
	Discharge Coefficient	Opening Area (m^2)	Internal Wall Area (m^2)
BCG01	0.63	0.60	23.90
BEG01	0.65	4.63	16.98
BEG02	0.65	3.38	14.35
BEG03	0.65	4.63	16.98
BEG04	0.65	3.38	14.35
BEG05	0.65	4.63	16.98
ABG02	0.63	0.60	23.90
AEG01	0.64	1.83	12.65
ANH01	0.65	4.34	15.75
ANH02	0.66	4.29	11.00
ANH03	0.65	3.54	15.26
ANH04	0.66	5.42	15.95
ANH05	0.66	4.29	11.00
ANH06	0.65	4.34	15.75
AWH01	0.64	1.83	12.65
ABH01	0.63	0.60	23.90
BWH01	0.66	5.59	14.71
BWH02	0.64	1.54	9.21
BWH03	0.66	5.59	14.71
BWH04	0.64	1.54	9.21
BWH05	0.66	5.59	14.71
CWH01	0.67	4.38	10.55
CWH02	0.67	4.38	10.55
CWH03	0.68	3.61	7.22
CWH04	0.68	3.61	7.22
CSH01	0.63	0.68	24.61
CEH01	0.65	4.63	16.98
CEH02	0.65	3.38	14.35
CEH03	0.65	4.63	16.98
CEH04	0.65	3.38	14.35
CEH05	0.65	4.63	16.98
BCH01	0.63	0.60	23.90
BEH01	0.65	4.63	16.98
BEH02	0.65	3.38	14.35
BEH03	0.65	4.63	16.98
BEH04	0.65	3.38	14.35
BEH05	0.65	4.63	16.98
ABH02	0.63	0.60	23.90
AEH01	0.64	1.83	12.65
CWI01	0.68	3.61	7.22
CWI02	0.68	8.64	17.77
CWI03	0.65	3.22	10.18
CWI04	0.68	12.43	25.51
CSI01	0.63	0.58	16.16
CSI02	0.63	0.58	18.63
CEI01	0.65	3.76	20.21
CEI02	0.66	7.06	17.88

Appendix B1 - Window Opening Sizes

Tap id	Configuration 1		
	Discharge Coefficient	Opening Area (m^2)	Internal Wall Area (m^2)
CEI03	0.66	3.94	9.76
CEI04	0.70	8.35	15.13
BCI01	0.63	0.60	23.90
ANJ01	0.65	4.34	15.75
ANJ02	0.66	4.29	11.00
ANJ03	0.65	3.54	15.26
ANJ04	0.66	5.42	15.95
ANJ05	0.66	4.29	11.00
ANJ06	0.65	4.34	15.75
AWJ01	0.64	1.83	12.65
ABJ01	0.63	0.60	23.90
BWJ01	0.66	5.59	14.71
BWJ02	0.64	1.54	9.21
BWJ03	0.66	5.59	14.71
BWJ04	0.64	1.54	9.21
BWJ05	0.66	5.59	14.71
BSJ01	0.63	0.60	23.90
BEJ01	0.65	4.63	16.98
BEJ02	0.65	3.38	14.35
BEJ03	0.65	4.63	16.98
BEJ04	0.65	3.38	14.35
BEJ05	0.65	4.63	16.98
ABJ02	0.63	0.60	23.90
AEJ01	0.64	1.83	12.65
ABK01	0.63	0.60	23.90
BWK01	0.70	8.35	15.13
BWK02	0.66	3.94	9.76
BWK03	0.66	7.06	17.88
BWK04	0.65	3.76	20.21
BEK01	0.65	3.76	20.21
BEK02	0.66	7.06	17.88
BEK03	0.66	3.94	9.76
BEK04	0.70	8.35	15.13
ABK02	0.63	0.60	23.90
CWH05	0.68	3.61	7.22
CWH06	0.67	4.38	10.55
CSH02	0.63	0.68	24.61
CEH06	0.67	4.38	10.55
BEH06	0.67	4.38	10.55
CWI05	0.70	5.55	9.65
CEI05	0.70	4.90	8.53
AWJ02	0.64	0.85	8.25
AEJ02	0.64	0.85	8.25
BWJ06	0.64	1.54	9.21
BWJ07	0.64	0.58	7.11
BEJ06	0.65	3.38	14.35
ANK01	0.69	14.58	26.68

Appendix B1 - Window Opening Sizes

Tap id	Configuration 1		
	Discharge Coefficient	Opening Area (m^2)	Internal Wall Area (m^2)
ANK02	0.67	12.31	26.68
ANK03	0.68	12.57	24.61
ANK04	0.67	10.20	24.61
ANK05	0.69	14.58	26.68
ANK06	0.67	12.31	26.68
AWK01	0.63	0.55	12.65
AWK02	0.64	1.46	8.25
BWK05	0.70	4.90	8.53
BEK05	0.70	4.90	8.53
AEK01	0.64	1.46	12.65
AEK02	0.64	0.74	8.25
AWG02	0.64	0.85	8.25
AEG02	0.64	0.85	8.25
BWG06	0.64	1.54	9.21
BWG07	0.68	3.61	7.22
CWG05	0.68	3.61	7.22
CWG06	0.64	1.54	9.21
CSG02	0.63	0.68	24.61
CEG06	0.64	1.54	9.21
BEG06	0.64	1.54	9.21
AWH02	0.64	0.85	8.25
AEH02	0.64	0.85	8.25
BWH06	0.64	1.54	9.21
BWH07	0.68	3.61	7.22

Appendix B2 - Internal Flow Path

Unit Number	Corner or Double Ended	Volume of Unit (m3)	Flow Path	External Opening 1	Opening Config	External Opening 2	Opening Config	Internal Opening 1	Internal Opening 1 Area	Internal Opening Type 2	Internal Opening 2 Area
2.01	NO	227	1	BWA04	1	BWA05	1	0.65	1.6	0.8	2.8
2.02	NO	236	1	BWA02	1	BWA03	1	0.65	1.6	0.8	2.8
2.03	NO	236	1	BWA06	1	BWA01	1	0.65	1.6	0.8	2.8
2.04	NO	149	1	DEA01	1	DSA06	1	0.65	1.6	0.7	1.6
2.04	NO	149	2	DSA03	1	DSA06	1	0.65	1.6		
2.05	NO	149	1	DSA06	1	DSA05	1	0.65	1.6		
2.06	NO	149	1	DSA02	1	DSA01	1	0.65	1.6		
2.07	NO	149	1	DSA04	1	DSA01	1	0.65	1.6		
2.08	NO	149	1	DNA02	1	DNA01	1	0.65	1.6		
2.09	NO	149	1	DNA02	1	DNA01	1	0.65	1.6		
2.10	NO	208	1	DNA03	1	CWA04	1	0.65	1.6		
2.11	NO	168	1	CWA03	1	CWA04	1	0.65	1.6		
2.12	NO	156	1	CWA02	1	CWA01	1	0.65	1.6		
2.12	NO	156	2	CWA02	1	CWA01	1	0.65	1.6		
3.01	NO	227	1	BWA04	1	BWA05	1	0.65	1.6	0.8	2.8
3.02	NO	236	1	BWA02	1	BWA03	1	0.65	1.6	0.8	2.8
3.03	NO	236	1	BWA06	1	BWA01	1	0.65	1.6	0.8	2.8
3.03	NO	236	2	BWA06	1	ABB01	1	0.65	1.6	0.7	1.6
3.04	YES	278	1	AWB02	1	ANB06	1	0.65	1.6	0.65	1.6
3.04	YES	278	2	AWB02	1	ANB05	1	0.65	1.6	0.65	2.9
3.04	YES	278	3	AWB01	1	ANB06	1	0.65	1.6	0.65	1.6
3.04	YES	278	4	AWB01	1	ANB05	1	0.65	1.6	0.65	2.9
3.05	NO	263	1	ANB04	1	ANB03	1	0.65	1.6	0.8	2.8
3.06	YES	278	1	AEB02	1	ANB01	1	0.65	1.6	0.65	1.6
3.06	YES	278	2	AEB02	1	ANB02	1	0.65	1.6	0.7	2.9
3.06	YES	278	3	AEB01	1	ANB01	1	0.65	1.6	0.65	1.6
3.06	YES	278	4	AEB01	1	ANB02	1	0.65	1.6	0.7	2.9
3.07	NO	149	1	DEA01	1	DSA06	1	0.65	1.6	0.7	1.6
3.07	NO	149	2	DSA03	1	DSA06	1	0.65	1.6		
3.08	NO	149	1	DSA06	1	DSA05	1	0.65	1.6		

Appendix B2 - Internal Flow Path

Unit Number	Corner or Double Ended	Volume of Unit (m3)	Flow Path	External Opening 1	Opening Config	External Opening 2	Opening Config	Internal Opening 1	Internal Opening 1 Area	Internal Opening Type 2	Internal Opening 2 Area
3.09	NO	149	1	DSA02	1	DSA01	1	0.65	1.6		
3.10	NO	149	1	DSA04	1	DSA01	1	0.65	1.6		
3.11	NO	149	1	DNA02	1	DNA01	1	0.65	1.6		
3.12	NO	149	1	DNA02	1	DNA01	1	0.65	1.6		
3.13	NO	207.6	1	DNA03	1	CWA04	1	0.65	1.6		
3.14	NO	168	1	CWA03	1	CWA04	1	0.65	1.6		
3.15	NO	156	1	CWA02	1	CWA01	1	0.65	1.6		
3.15	NO	156	2	CWA02	1	CWA01	1	0.65	1.6		
4.01	NO	227	1	BWB05	1	BWB04	1	0.65	1.6	0.8	2.8
4.02	NO	236	1	BWB03	1	BWB02	1	0.65	1.6	0.8	2.8
4.03	NO	236	1	BWB01	1	BWB06	1	0.65	1.6	0.8	2.8
4.03	NO	236	2	BWB06	1	ABB01	1	0.65	1.6	0.7	1.6
4.04	YES	278	1	AWB02	1	ANB05	1	0.65	1.6	0.65	1.6
4.04	YES	278	2	AWB02	1	ANB06	1	0.65	1.6	0.65	2.9
4.04	YES	278	3	AWB01	1	ANB05	1	0.65	1.6	0.65	1.6
4.04	YES	278	4	AWB01	1	ANB06	1	0.65	1.6	0.65	2.9
4.05	NO	263.3	1	ANB04	1	ANB03	1	0.65	1.6	0.8	2.8
4.06	YES	278	1	AEB02	1	ANB01	1	0.65	1.6	0.65	1.6
4.06	YES	278	2	AEB02	1	ANB02	1	0.65	1.6	0.7	2.9
4.06	YES	278	3	AEB01	1	ANB01	1	0.65	1.6	0.65	1.6
4.06	YES	278	4	AEB01	1	ANB02	1	0.65	1.6	0.7	2.9
4.07	NO	231	1	BEB05	1	BEB06	1	0.65	1.6	0.65	2.4
4.07	NO	231	2	ABB02	1	BEB05	1	0.65	1.6	0.65	2.4
4.08	NO	231	1	BEB03	1	BEB04	1	0.65	1.6	0.8	2.8
4.09	NO	231	1	BEB01	1	BEB02	1	0.65	1.6	0.8	2.8
4.09	NO	231	2	BCB01	1	BEB02	1	0.65	1.6	0.8	2.8
4.10	NO	231	1	BCB01	1	CEB05	1	0.65	1.6	0.8	2.8
4.10	NO	231	2	CEB06	1	CEB05	1	0.65	1.6	0.8	2.8
4.11	NO	231	1	CEB03	1	CEB04	1	0.65	1.6	0.8	2.8
4.12	YES	231	1	CEB01	1	CEB02	1	0.65	1.6	0.8	2.8

Appendix B2 - Internal Flow Path

Unit Number	Corner or Double Ended	Volume of Unit (m3)	Flow Path	External Opening 1	Opening Config	External Opening 2	Opening Config	Internal Opening 1	Internal Opening 1 Area	Internal Opening Type 2	Internal Opening 2 Area
4.12	YES	231	2	CSB01	1	CEB02	1	0.65	1.6	0.8	2.8
4.13	NO	149	1	DEB01	1	DSB06	1	0.65	1.6	0.7	1.6
4.13	NO	149	2	DSB03	1	DSB06	1	0.65	1.6		
4.14	NO	149	1	DSB05	1	DSB06	1	0.65	1.6		
4.15	NO	149	1	DSB01	1	DSB02	1	0.65	1.6		
4.16	NO	149	1	DSB01	1	DSB04	1	0.65	1.6		
4.17	NO	149	1	DNB02	1	DNB01	1	0.65	1.6		
4.18	NO	149	1	DNB02	1	DNB01	1	0.65	1.6		
4.19	NO	207.6	1	DNB03	1	CWB03	1	0.65	1.6		
4.20	NO	168	1	CWB01	1	CWB02	1	0.65	1.6		
4.21	NO	156	1	CWB01	1	BWB07	1	0.65	1.6		
7.01	NO	227	1	BWC05	1	BWC04	1	0.65	1.6	0.8	2.8
7.02	NO	236	1	BWC03	1	BWC02	1	0.65	1.6	0.8	2.8
7.03	NO	236	1	BWC01	1	BWC06	1	0.65	1.6	0.8	2.8
7.03	NO	236	2	BWC06	1	ABC01	1	0.65	1.6	0.7	1.6
7.04	YES	278	1	AWC02	1	ANC05	1	0.65	1.6	0.65	1.6
7.04	YES	278	2	AWC02	1	ANC06	1	0.65	1.6	0.65	2.9
7.04	YES	278	3	AWC01	1	ANC05	1	0.65	1.6	0.65	1.6
7.04	YES	278	4	AWC01	1	ANC06	1	0.65	1.6	0.65	2.9
7.05	NO	263.3	1	ANC04	1	ANC03	1	0.65	1.6	0.8	2.8
7.06	YES	278	1	AEC02	1	ANC01	1	0.65	1.6	0.65	1.6
7.06	YES	278	2	AEC02	1	ANC02	1	0.65	1.6	0.7	2.9
7.06	YES	278	3	AEC01	1	ANC01	1	0.65	1.6	0.65	1.6
7.06	YES	278	4	AEC01	1	ANC02	1	0.65	1.6	0.7	2.9
7.07	NO	231	1	BEC06	1	BEC05	1	0.65	1.6	0.65	2.4
7.07	NO	231	2	ABC02	1	BEC05	1	0.65	1.6	0.65	2.4
7.08	NO	231	1	BEC04	1	BEC03	1	0.65	1.6	0.8	2.8
7.09	NO	231	1	BCC01	1	BEC02	1	0.65	1.6	0.8	2.8
7.09	NO	231	2	BEC01	1	BEC02	1	0.65	1.6	0.8	2.8
7.10	NO	231	1	BCC01	1	CEC05	1	0.65	1.6	0.8	2.8

Appendix B2 - Internal Flow Path

Unit Number	Corner or Double Ended	Volume of Unit (m3)	Flow Path	External Opening 1	Opening Config	External Opening 2	Opening Config	Internal Opening 1	Internal Opening 1 Area	Internal Opening Type 2	Internal Opening 2 Area
7.10	NO	231	2	CEC06	1	CEC05	1	0.65	1.6	0.8	2.8
7.11	NO	231	1	CEC04	1	CEC03	1	0.65	1.6	0.8	2.8
7.12	YES	231	1	CSC01	1	CEC02	1	0.65	1.6	0.8	2.8
7.12	YES	231	2	CEC01	1	CEC02	1	0.65	1.6	0.8	2.8
7.13	NO	149	1	DSC06	1	DEC01	1	0.65	1.6	0.7	1.6
7.13	NO	149	2	DSC03	1	DSC06	1	0.65	1.6		
7.14	NO	149	1	DSC05	1	DSC02	1	0.65	1.6		
7.15	NO	149	1	DSC05	1	DSC02	1	0.65	1.6		
7.16	NO	149	1	DSC01	1	DSC04	1	0.65	1.6		
7.17	NO	149	1	DNC02	1	DNC01	1	0.65	1.6		
7.18	NO	149	1	DNC02	1	DNC01	1	0.65	1.6		
7.19	NO	207.6	1	DNC03	1	CWC03	1	0.65	1.6		
7.20	NO	168	1	CWC02	1	CWC01	1	0.65	1.6		
7.21	NO	156	1	CWC01	1	BWC07	1	0.65	1.6		
9.13	NO	231	1	DSD06	1	DED01	1	0.65	1.6		
9.14	NO	171	1	DSD03	1	DSC06	1	0.65	1.6		
9.15	NO	171	1	DSD03	1	DSC06	1	0.65	1.6		
9.16	YES	260	1	DSD05	1	DND01	1	0.65	1.6		
10.01	NO	245	1	BWC04	1	BWC05	1	0.65	1.6	0.8	2.8
10.01	NO	245	2	BWC04	1	BWC07	1	0.65	1.6	0.8	2.8
10.02	NO	236	1	BWC02	1	BWC03	1	0.65	1.6	0.8	2.8
10.03	NO	236	1	BWC01	1	BWC06	1	0.65	1.6	0.8	2.8
10.03	NO	236	2	BWC06	1	ABC01	1	0.65	1.6	0.7	1.6
10.04	YES	278	1	AWC02	1	ANC05	1	0.65	1.6	0.65	1.6
10.04	YES	278	2	AWC02	1	ANC06	1	0.65	1.6	0.65	2.9
10.04	YES	278	3	AWC01	1	ANC05	1	0.65	1.6	0.65	1.6
10.04	YES	278	4	AWC01	1	ANC06	1	0.65	1.6	0.65	2.9
10.05	NO	263.3	1	ANC03	1	ANC04	1	0.65	1.6	0.8	2.8
10.06	YES	278	1	AEC01	1	ANC01	1	0.65	1.6	0.65	1.6
10.06	YES	278	2	AEC01	1	ANC02	1	0.65	1.6	0.7	2.9

Appendix B2 - Internal Flow Path

Unit Number	Corner or Double Ended	Volume of Unit (m3)	Flow Path	External Opening 1	Opening Config	External Opening 2	Opening Config	Internal Opening 1	Internal Opening 1 Area	Internal Opening Type 2	Internal Opening 2 Area
10.06	YES	278	3	AEC02	1	ANC01	1	0.65	1.6	0.65	1.6
10.06	YES	278	4	AEC02	1	ANC02	1	0.65	1.6	0.7	2.9
10.07	NO	231	1	ABC02	1	BEC06	1	0.65	1.6	0.65	2.4
10.07	NO	231	2	BEC06	1	BEC05	1	0.65	1.6	0.65	2.4
10.08	NO	231	1	BEC03	1	BEC04	1	0.65	1.6	0.8	2.8
10.09	NO	231	1	BEC02	1	BCC01	1	0.65	1.6	0.8	2.8
10.09	NO	231	2	BEC01	1	BEC02	1	0.65	1.6	0.8	2.8
10.10	NO	231	1	BCC01	1	CEC06	1	0.65	1.6	0.8	2.8
10.10	NO	231	2	CEC06	1	CEC05	1	0.65	1.6	0.8	2.8
10.11	NO	231	1	CEC03	1	CEC04	1	0.65	1.6	0.8	2.8
10.12	YES	231	1	CSD01	1	CEC02	1	0.65	1.6	0.8	2.8
10.15	NO	207.6	1	DND03	1	CWC03	1	0.65	1.6		
10.16	NO	184	1	CWC01	1	CWC02	1	0.65	1.6		
10.17	NO	156	1	CWC01	1	BWC07	1	0.65	1.6		
11.13	YES	195	1	DSD04	1	CWE01	1	0.7	4.1		
11.13	YES	195	2	DSD04	1	CWE02	1	0.65	1.6		
11.14	NO	152	1	CWF01	1	CWF02	1	0.65	1.6	0.8	2.8
13.01	NO	245	1	BWF07	1	BWF04	1	0.65	1.6	0.8	2.8
13.01	NO	245	2	BWF07	1	BWF05	1	0.65	1.6	0.8	2.8
13.02	NO	236	1	BWF02	1	BWF03	1	0.65	1.6	0.8	2.8
13.03	NO	236	1	BWF01	1	BWF06	1	0.65	1.6	0.65	1.6
13.03	NO	236	2	BWF06	1	ABF01	1	0.65	1.6	0.7	1.6
13.04	YES	278	1	AWF01	1	ANF05	1	0.65	1.6	0.65	2.9
13.04	YES	278	2	AWF01	1	ANF06	1	0.65	1.6	0.65	1.6
13.04	YES	278	3	AWF02	1	ANF05	1	0.65	1.6	0.65	2.9
13.04	YES	278	4	AWF02	1	ANF06	1	0.65	1.6	0.8	2.8
13.05	NO	263.3	1	ANF03	1	ANF04	1	0.65	1.6	0.65	1.6
13.06	YES	278	1	AEF01	1	ANF01	1	0.65	1.6	0.7	2.9
13.06	YES	278	2	AEF01	1	ANF02	1	0.65	1.6	0.65	1.6
13.06	YES	278	3	AEF02	1	ANF01	1	0.65	1.6	0.7	2.9

Appendix B2 - Internal Flow Path

Unit Number	Corner or Double Ended	Volume of Unit (m3)	Flow Path	External Opening 1	Opening Config	External Opening 2	Opening Config	Internal Opening 1	Internal Opening 1 Area	Internal Opening Type 2	Internal Opening 2 Area
13.06	YES	278	4	AEF02	1	ANF02	1	0.65	1.6	0.8	2.8
13.07	NO	231	1	BEF05	1	BEF06	1	0.65	1.6	0.65	2.4
13.07	NO	231	2	ABF02	1	BEF05	1	0.65	1.6	0.65	2.4
13.08	NO	231	1	BEF03	1	BEF04	1	0.65	1.6	0.8	2.8
13.09	NO	231	1	BCF01	1	BEF01	1	0.65	1.6	0.8	2.8
13.09	NO	231	2	BCF01	1	BEF02	1	0.65	1.6	0.8	2.8
13.10	NO	231	1	BCF01	1	CEF05	1	0.65	1.6	0.8	2.8
13.10	NO	231	2	BCF01	1	CEF06	1	0.65	1.6	0.8	2.8
13.11	NO	231	1	CEF03	1	CEF04	1	0.65	1.6	0.8	2.8
13.12	YES	231	1	CSF01	1	CEF01	1				
13.12	YES	231	2	CSF01	1	CEF02	1	0.65	1.6	0.8	2.8
13.13	NO	140	1	CSF02	1	CWF04	1	0.65	1.6		
13.13	NO	140	2	CSF02	1	CWF06	1				
13.14	NO	151	1	CWF02	1	CWF03	1	0.65	1.6		
13.15	NO	151	1	CWF02	1	CWF05	1	0.65	1.6		
13.16	NO	158	1	CWF01	1	BWF07	1	0.7	1.6		
9.17	YES	260	1	DSD02	1	DND01	1	0.65	2.8		
9.18	NO	171	1	DSD04	1	DSC04	1	0.65	2.8		
9.19	YES	260	1	DSD01	1	DND02	1	0.65	2.8		
9.20	YES	260	1	DSD01	1	DND02	1	0.65	2.8		
17.01	NO	245	1	BWG07	1	BWG04	1	0.65	1.6	0.8	2.8
17.01	NO	245	2	BWG07	1	BWG05	1	0.65	1.6	0.8	2.8
17.02	NO	236	1	BWG02	1	BWG03	1	0.65	1.6	0.8	2.8
17.03	NO	236	1	BWG06	1	BWG01	1	0.65	1.6	0.65	1.6
17.04	YES	278	1	AWG01	1	ANG05	1	0.65	1.6	0.65	2.9
17.04	YES	278	2	AWG01	1	ANG06	1	0.65	1.6	0.65	1.6
17.04	YES	278	3	AWG02	1	ANG05	1	0.65	1.6	0.65	2.9
17.04	YES	278	4	AWG02	1	ANG06	1	0.65	1.6	0.8	2.8
17.05	NO	263.3	1	ANG04	1	ANG03	1	0.65	1.6	0.65	1.6
17.06	YES	278	1	AEG01	1	ANG01	1	0.65	1.6	0.7	2.9

Appendix B2 - Internal Flow Path

Unit Number	Corner or Double Ended	Volume of Unit (m3)	Flow Path	External Opening 1	Opening Config	External Opening 2	Opening Config	Internal Opening 1	Internal Opening 1 Area	Internal Opening Type 2	Internal Opening 2 Area
17.06	YES	278	2	AEG01	1	ANG02	1	0.65	1.6	0.65	1.6
17.06	YES	278	3	AEG02	1	ANG01	1	0.65	1.6	0.7	2.9
17.06	YES	278	4	AEG02	1	ANG02	1	0.65	1.6	0.8	2.8
17.07	NO	231	1	BEG05	1	BEG06	1	0.65	1.6	0.65	2.4
17.07	NO	231	2	ABG02	1	BEG05	1	0.65	1.6	0.65	2.4
17.08	NO	231	1	BEG03	1	BEG04	1	0.65	1.6	0.8	2.8
17.09	NO	231	1	BCG01	1	BEG01	1	0.65	1.6	0.8	2.8
17.09	NO	231	2	BCG01	1	BEG02	1	0.65	1.6	0.8	2.8
17.10	NO	231	1	BCG01	1	CEG05	1	0.65	1.6	0.8	2.8
17.10	NO	231	2	BCG01	1	CEG06	1	0.65	1.6	0.8	2.8
17.11	NO	231	1	CEG03	1	CEG04	1	0.65	1.6	0.8	2.8
17.12	YES	231	1	CSG01	1	CEG01	1				
17.12	YES	231	2	CSG01	1	CEG02	1	0.65	1.6	0.8	2.8
17.13	YES	140	1	CSG02	1	CWG04	1	0.65	1.6		
17.13	YES	140	2	CSG02	1	CWG06	1				
17.14	NO	151	1	CWG03	1	CWG02	1	0.65	1.6		
17.15	NO	151	1	CWG02	1	CWG05	1	0.65	1.6		
17.16	NO	158	1	CWG01	1	BWG07	1	0.7	1.6		
20.01	NO	245	1	BWH07	1	BWH04	1	0.65	1.6	0.8	2.8
20.01	NO	245	2	BWH07	1	BWH05	1	0.65	1.6	0.8	2.8
20.02	NO	236	1	BWH02	1	BWH03	1	0.65	1.6	0.8	2.8
20.03	NO	236	1	BWH06	1	BWH01	1	0.65	1.6	0.65	1.6
20.04	YES	278	1	AWH01	1	ANH05	1	0.65	1.6	0.65	2.9
20.04	YES	278	2	AWH01	1	ANH06	1	0.65	1.6	0.65	1.6
20.04	YES	278	3	AWH02	1	ANH05	1	0.65	1.6	0.65	2.9
20.04	YES	278	4	AWH02	1	ANH06	1	0.65	1.6	0.8	2.8
20.05	NO	263.3	1	ANH03	1	ANH04	1	0.65	1.6	0.65	1.6
20.06	YES	278	1	AEH01	1	ANH01	1	0.65	1.6	0.7	2.9
20.06	YES	278	2	AEH01	1	ANH02	1	0.65	1.6	0.65	1.6
20.06	YES	278	3	AEH02	1	ANH01	1	0.65	1.6	0.7	2.9

Appendix B2 - Internal Flow Path

Unit Number	Corner or Double Ended	Volume of Unit (m3)	Flow Path	External Opening 1	Opening Config	External Opening 2	Opening Config	Internal Opening 1	Internal Opening 1 Area	Internal Opening Type 2	Internal Opening 2 Area
20.06	YES	278	4	AEH02	1	ANH02	1	0.65	1.6	0.8	2.8
20.07	NO	231	1	BEH05	1	BEH06	1	0.65	1.6	0.65	2.4
20.07	NO	231	2	ABH02	1	BEH05	1	0.65	1.6	0.65	2.4
20.08	NO	231	1	BEH03	1	BEH04	1	0.65	1.64	0.8	2.75
20.09	NO	231	1	BCH01	1	BEH01	1	0.65	1.64	0.8	2.75
20.09	NO	231	2	BCH01	1	BEH02	1	0.65	1.64	0.8	2.75
20.10	NO	231	1	BCH01	1	CEH05	1	0.65	1.64	0.8	2.75
20.10	NO	231	2	BCH01	1	CEH06	1	0.65	1.64	0.8	2.75
20.11	NO	231	1	CEH03	1	CEH04	1	0.65	1.64	0.8	2.75
20.12	YES	231	1	CSH01	1	CEH01	1				
20.12	YES	231	2	CSH01	1	CEH02	1	0.65	1.64	0.8	2.75
20.13	YES	140	1	CSH02	1	CWH04	1	0.65	1.64		
20.13	YES	140	2	CSH02	1	CWH06	1				
20.14	NO	151	1	CWH03	1	CWH02	1	0.65	1.64		
20.15	NO	151	1	CWH02	1	CWH05	1	0.65	1.64		
20.16	NO	158	1	CWH01	1	BWH07	1	0.7	1.64		
21.10	NO	208	1	CEI04	1	CEI05	1	0.65	1.64		
21.11	YES	374	1	CSI02	1	CEI01	1				
21.11	YES	374	2	CSI02	1	CEI02	1	0.65	1.64		
21.11	YES	374	3	CSI02	1	CEI03	1	0.65	1.64	0.9	2.75
21.11	YES	374	4	CEI03	1	CEI01	1	0.65	1.64	0.9	2.75
21.12	YES	270	1	CSI01	1	CWI03	1	0.65	1.64	0.8	2.75
21.12	YES	270	2	CSI01	1	CWI04	1				
21.12	YES	270	3	CWI03	1	CWI04	1	0.65	1.64	0.7	2.75
21.13	NO	293	1	CWI02	1	CWI01	1	0.7	1.64	0.9	2.75
21.13	NO	293	2	CWI02	1	CWI05	1	0.65	1.64		
23.01	NO	245	1	BWJ04	1	BWJ07	1	0.65	1.64	0.65	2.8
23.01	NO	245	2	BWJ05	1	BWJ07	1				
23.02	NO	236	1	BWJ02	1	BWJ03	1	0.65	1.64	0.8	2.75
23.03	NO	236	1	BWJ06	1	BWJ01	1	0.65	1.64	0.8	2.75

Appendix B2 - Internal Flow Path

Unit Number	Corner or Double Ended	Volume of Unit (m3)	Flow Path	External Opening 1	Opening Config	External Opening 2	Opening Config	Internal Opening 1	Internal Opening 1 Area	Internal Opening Type 2	Internal Opening 2 Area
23.04	YES	278	1	AWJ01	1	ANJ05	1	0.65	1.6	0.65	2.9
23.04	YES	278	2	AWJ01	1	ANJ06	1	0.65	1.6	0.65	1.6
23.04	YES	278	3	AWJ02	1	ANJ05	1	0.65	1.6	0.65	2.9
23.04	YES	278	4	AWJ02	1	ANJ06	1	0.65	1.6	0.8	2.8
23.05	NO	263.3	1	ANJ03	1	ANJ04	1	0.65	1.6	0.65	1.6
23.06	YES	278	1	AEJ01	1	ANJ01	1	0.65	1.6	0.7	2.9
23.06	YES	278	2	AEJ01	1	ANJ02	1	0.65	1.6	0.65	1.6
23.06	YES	278	3	AEJ02	1	ANJ01	1	0.65	1.6	0.7	2.9
23.06	YES	278	4	AEJ02	1	ANJ02	1	0.65	1.6	0.8	2.8
23.07	NO	231	1	ABJ02	1	BEJ05	1	0.65	1.6	0.65	2.4
23.07	NO	231	2	ABJ02	1	BEJ06	1	0.65	1.6	0.65	2.4
23.08	NO	231	1	BEJ03	1	BEJ04	1	0.65	1.6	0.8	2.8
23.09	YES	231	1	BSJ01	1	BEJ01	1				
23.09	YES	231	2	BSJ01	1	BEJ02	1	0.65	1.6	0.7	2.8
24.01	NO	382	1	BWK04	1	BWK02	1	0.65	1.6	0.8	2.8
24.01	NO	382	2	BWK04	1	BWK03	1	0.65	1.6	0.8	2.8
24.02	NO	204	1	BWK01	1	BWK05	1	0.65	1.6		
24.03	YES	466	1	AWK01	1	ANK05	1	0.65	1.6		
24.03	YES	466	2	AWK01	1	ANK06	1	0.65	1.6	0.9	2.8
24.03	YES	466	3	AWK02	1	ANK05	1				
24.03	YES	466	4	AWK02	1	ANK06	1	0.9	2.8		
24.04	NO	453	1	ANK03	1	ANK04	1	0.65	1.6	0.9	2.8
24.05	YES	466	1	AEK01	1	ANK01	1	0.65	1.6	0.9	2.8
24.05	YES	466	2	AEK01	1	ANK02	1	0.65	1.6		
24.05	YES	466	3	AEK02	1	ANK01	1	0.65	1.6		
24.05	YES	466	4	AEK02	1	ANK02	1	0.65	1.6	0.9	2.8
24.06	NO	203	1	BEK05	1	BEK04	1	0.65	1.6		
24.07	NO	371	1	BEK03	1	BEK01	1	0.65	1.6	0.8	2.8
24.07	NO	371	2	BEK02	1	BEK01	1	0.65	1.6		

Appendix B2 - Internal Flow Path

Unit Number	Corner or Double Ended	Volume of Unit (m3)	Flow Path	External Opening 1	Opening Config	External Opening 2	Opening Config	Internal Opening 1	Internal Opening 1 Area	Internal Opening Type 2	Internal Opening 2 Area
24.07	NO	371	1	BEK03	1	BEK01	1	0.65	1.6	0.8	2.8
24.07	NO	371	2	BEK02	1	BEK01	1	0.65	1.6		

Appendix C

Internal Flow Path Diagrams

Figure C1: Internal Flow Path Diagram for Natural Ventilation - Level 2

Figure C2: Internal Flow Path Diagram for Natural Ventilation - Level 3

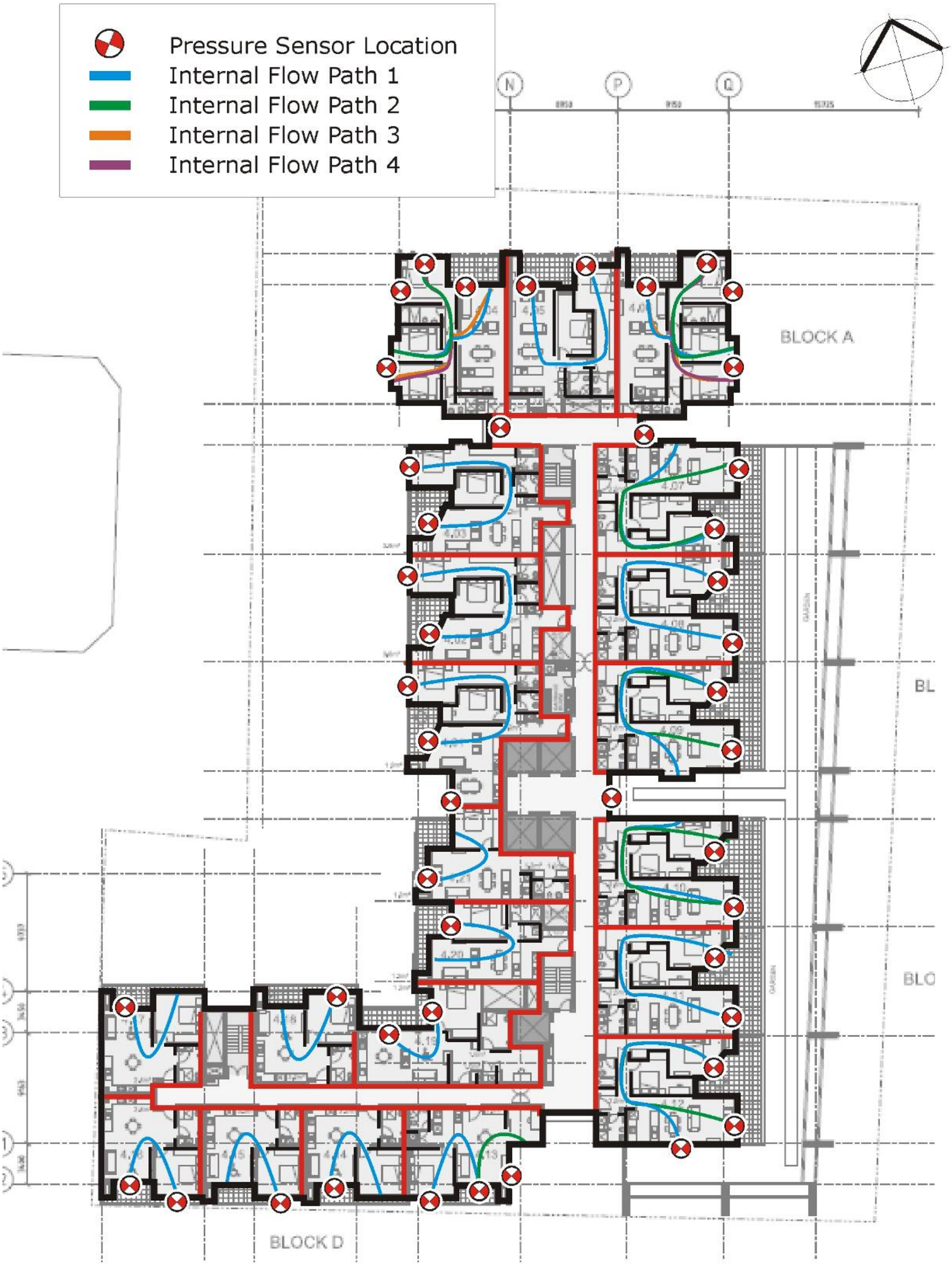


Figure C3: Internal Flow Path Diagram for Natural Ventilation - Level 4

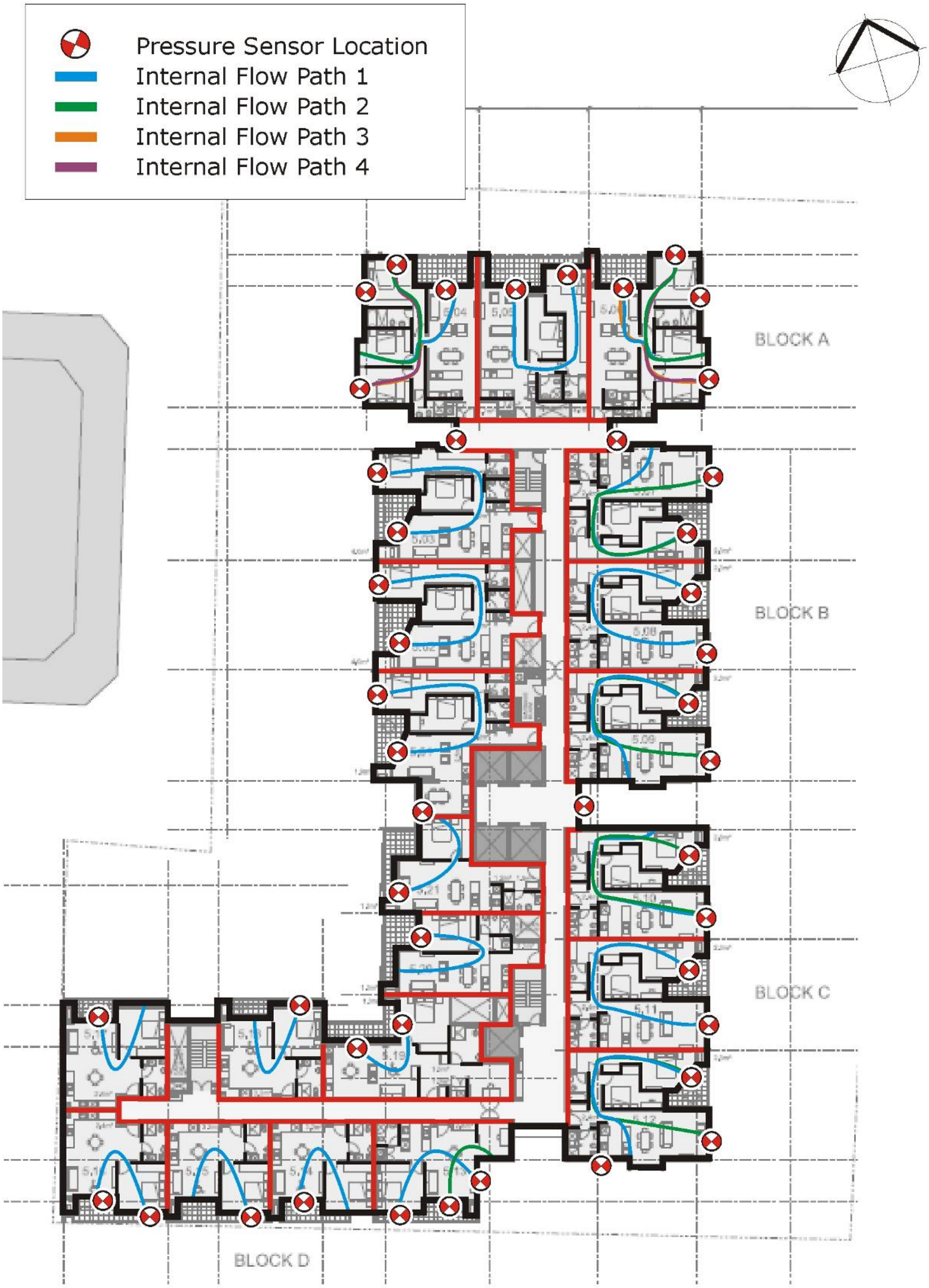


Figure C4: Internal Flow Path Diagram for Natural Ventilation - Level 8

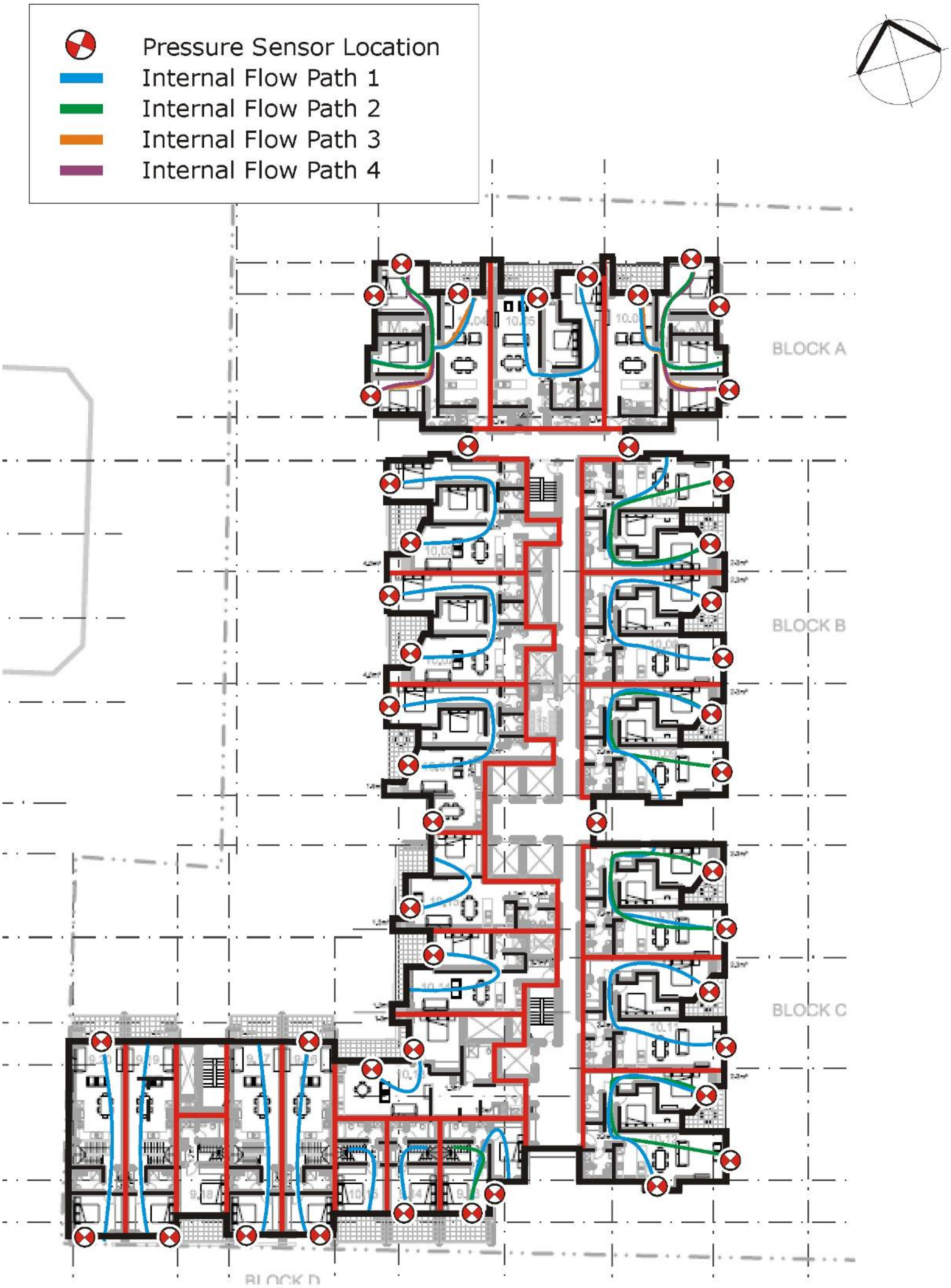


Figure C5: Internal Flow Path Diagram for Natural Ventilation - Level 10

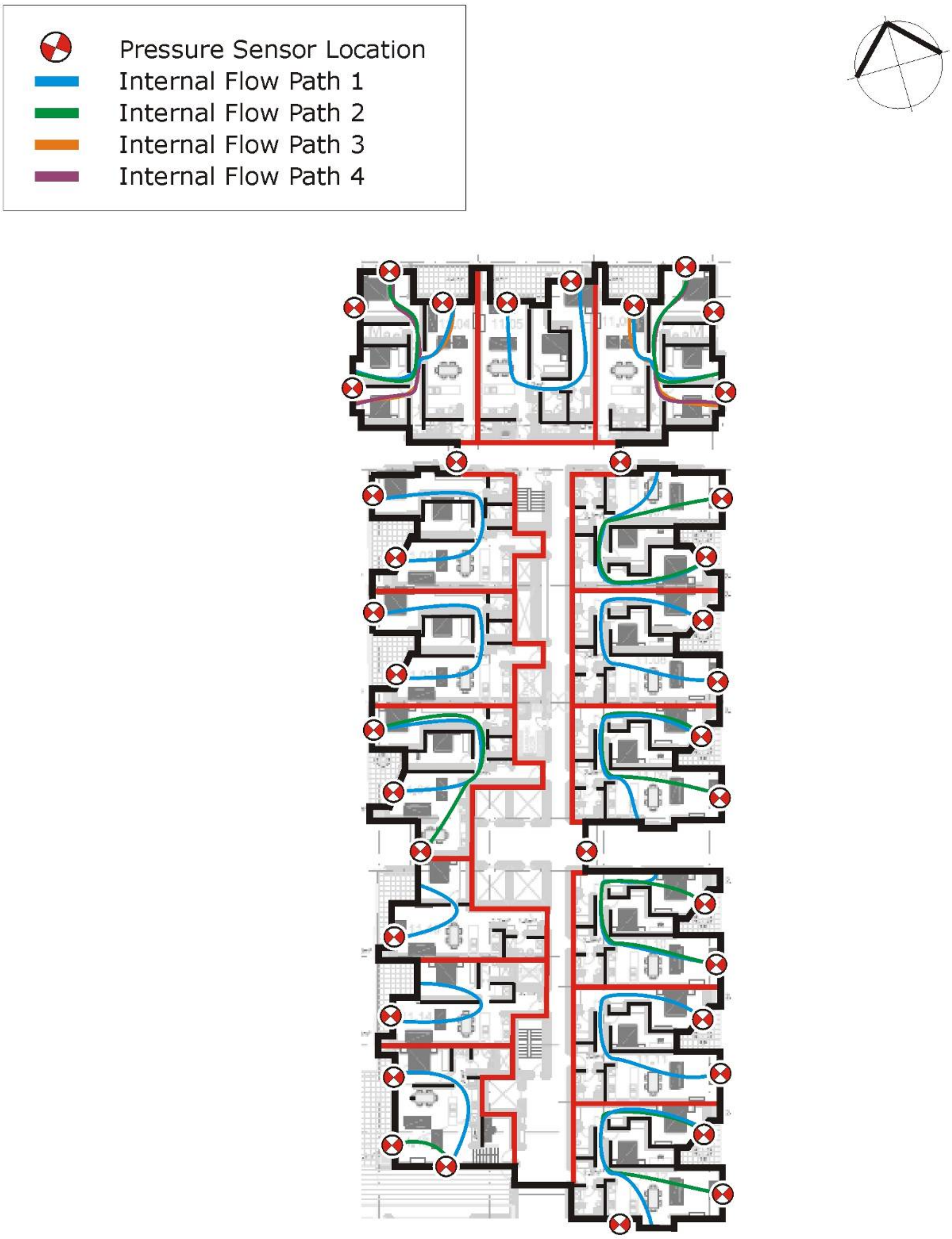


Figure C6: Internal Flow Path Diagram for Natural Ventilation - Level 11

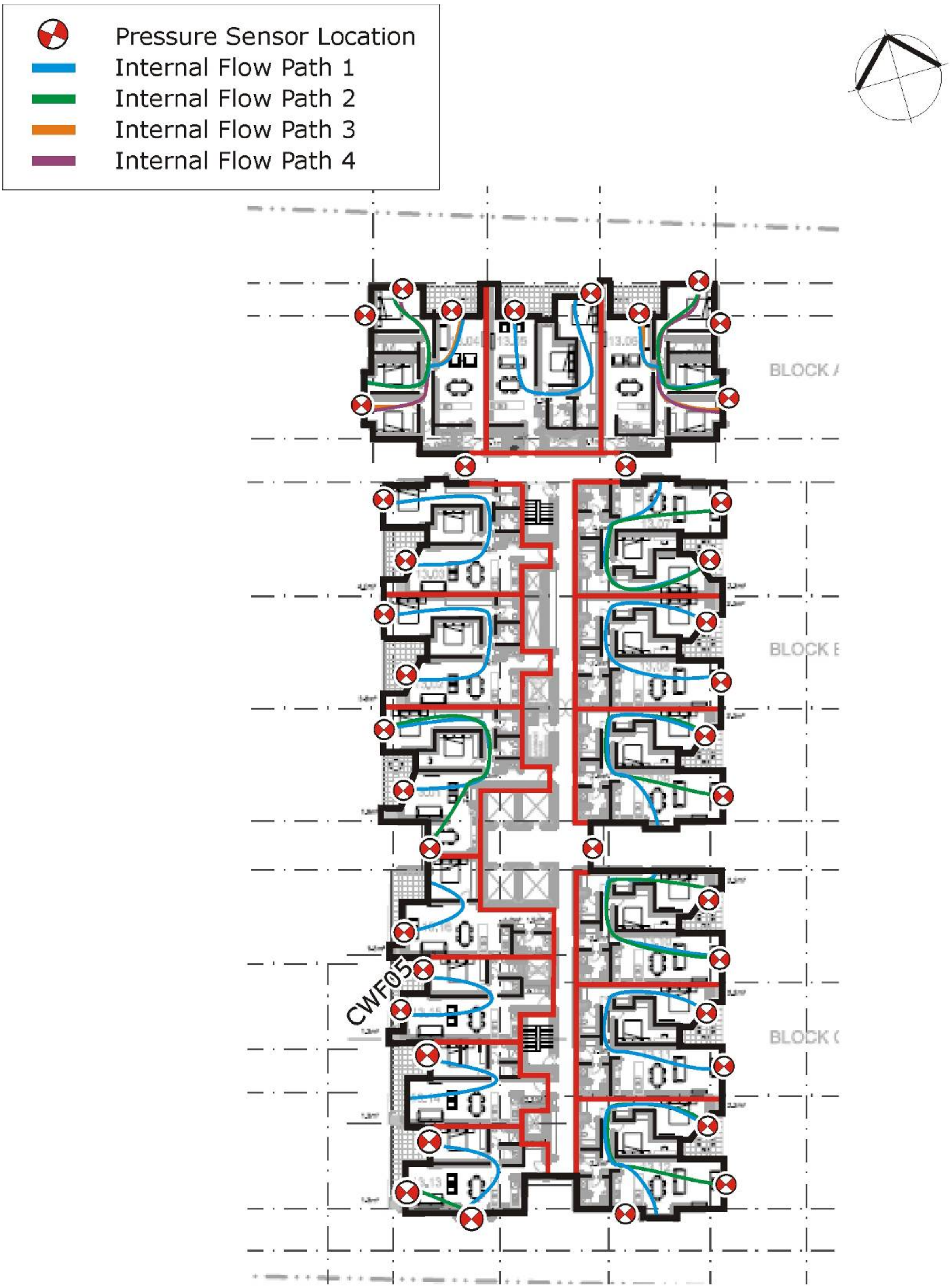


Figure C7: Internal Flow Path Diagram for Natural Ventilation - Level 13

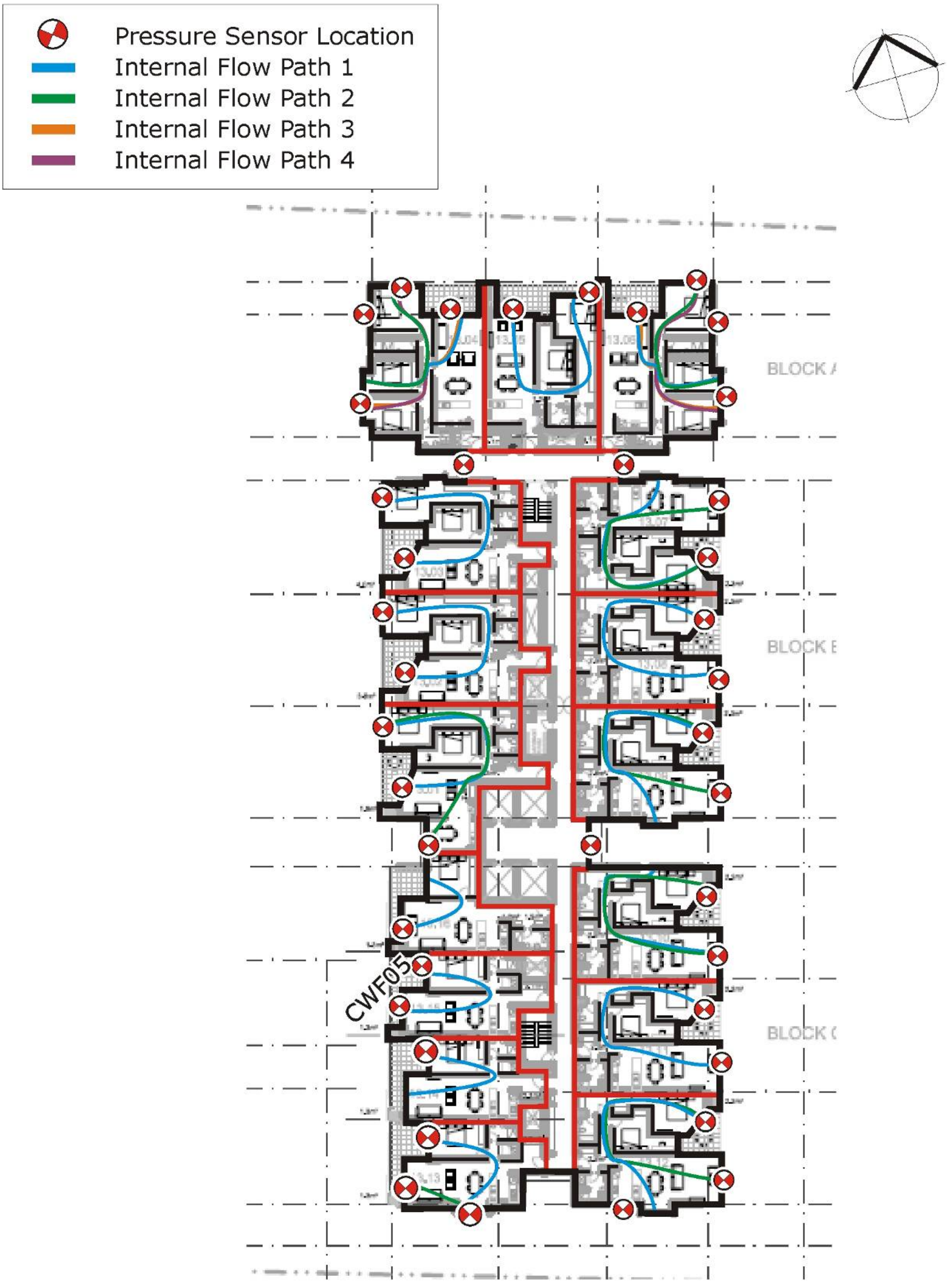


Figure C8: Internal Flow Path Diagram for Natural Ventilation - Level 17

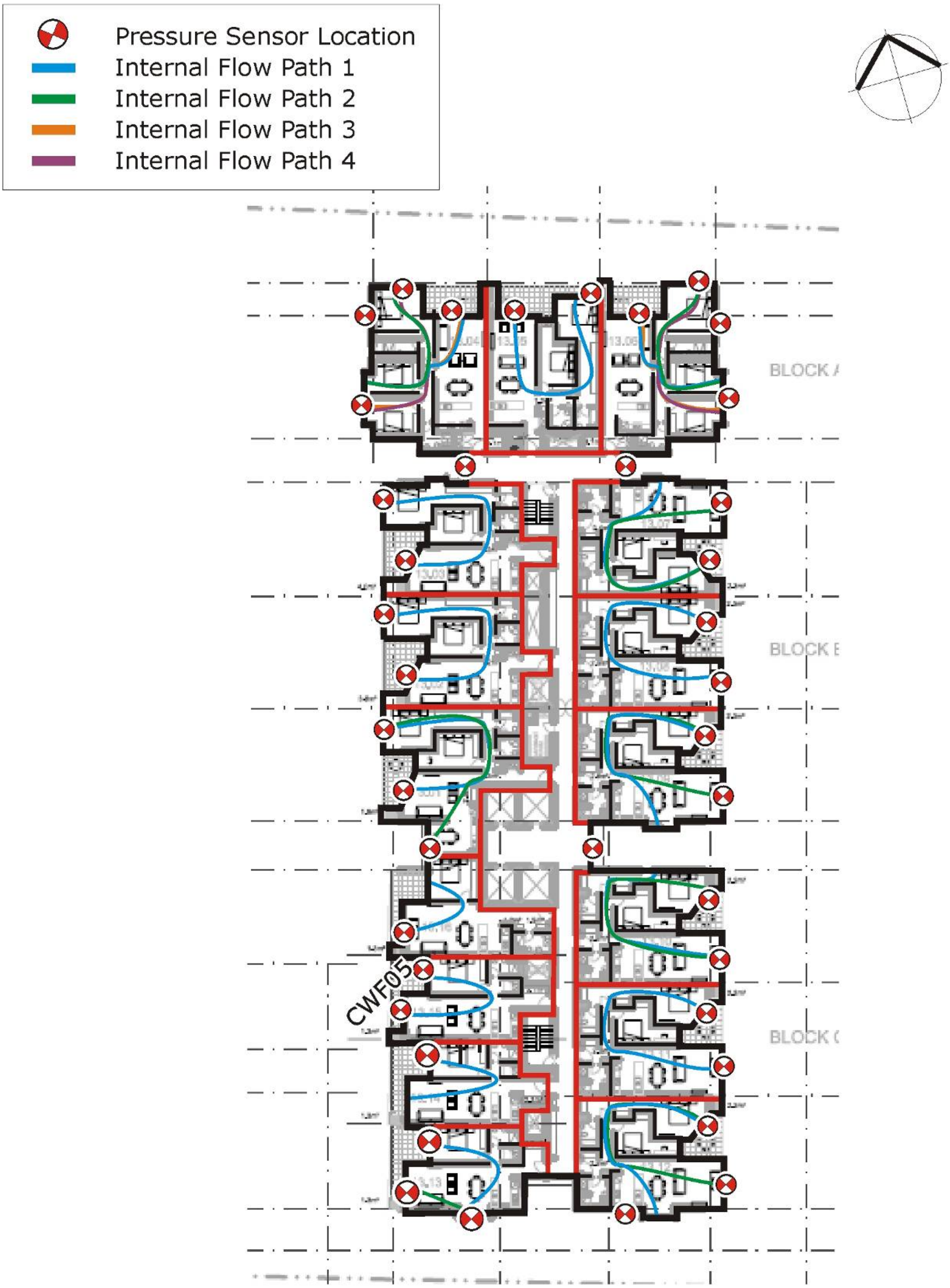


Figure C9: Internal Flow Path Diagram for Natural Ventilation - Level 20

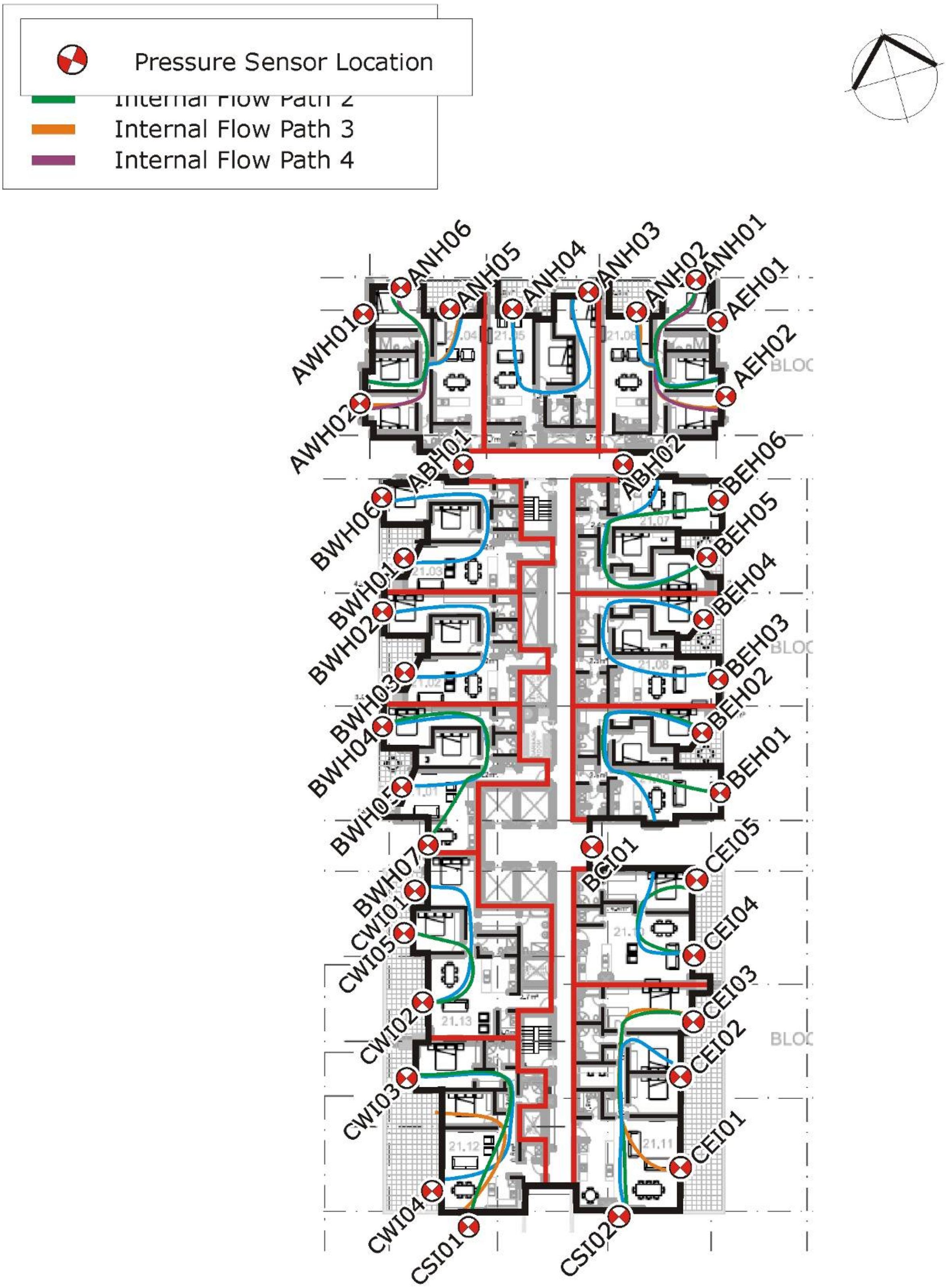


Figure C10: Internal Flow Path Diagram for Natural Ventilation - Level 21

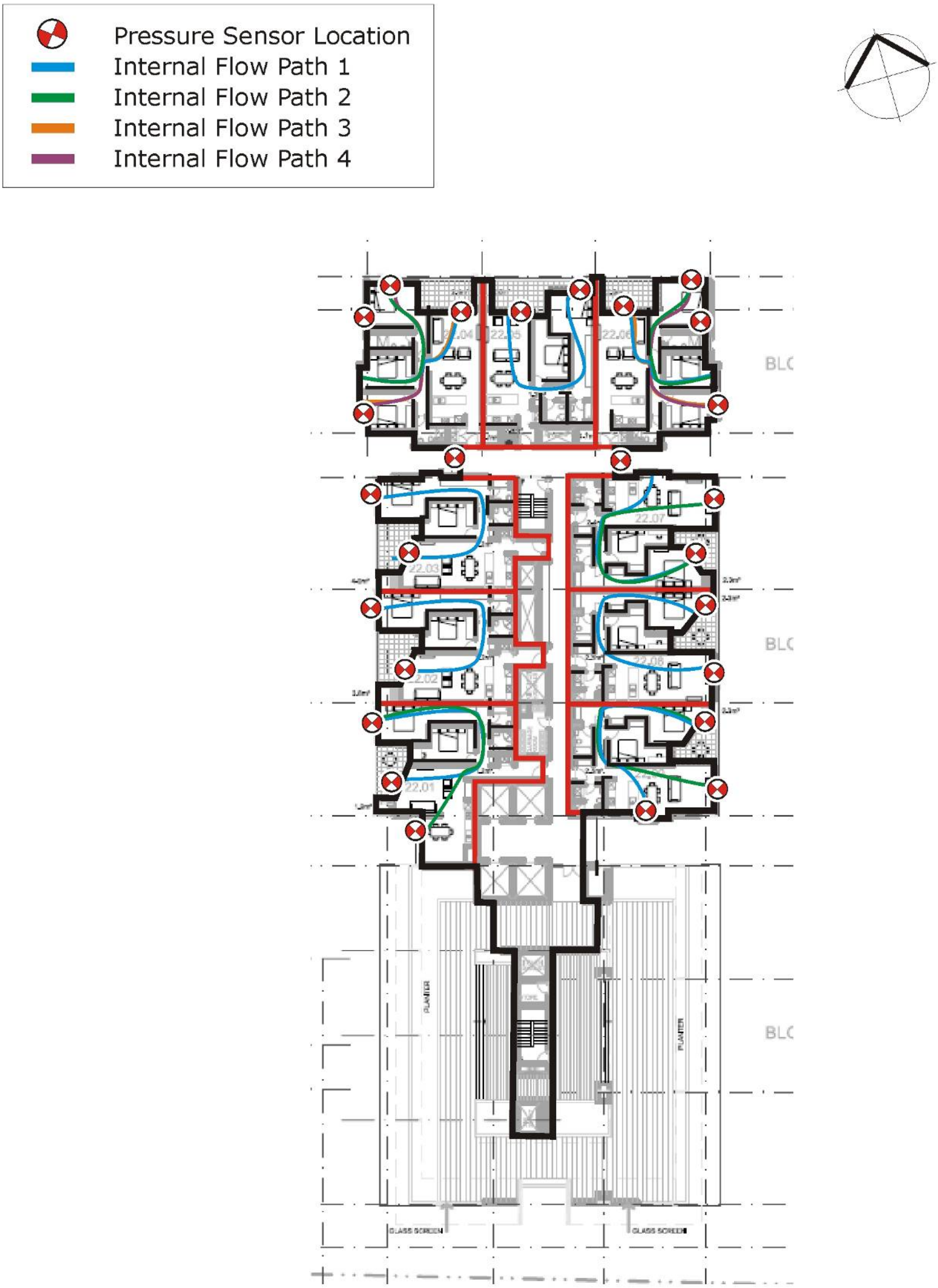


Figure C11: Internal Flow Path Diagram for Natural Ventilation - Level 22

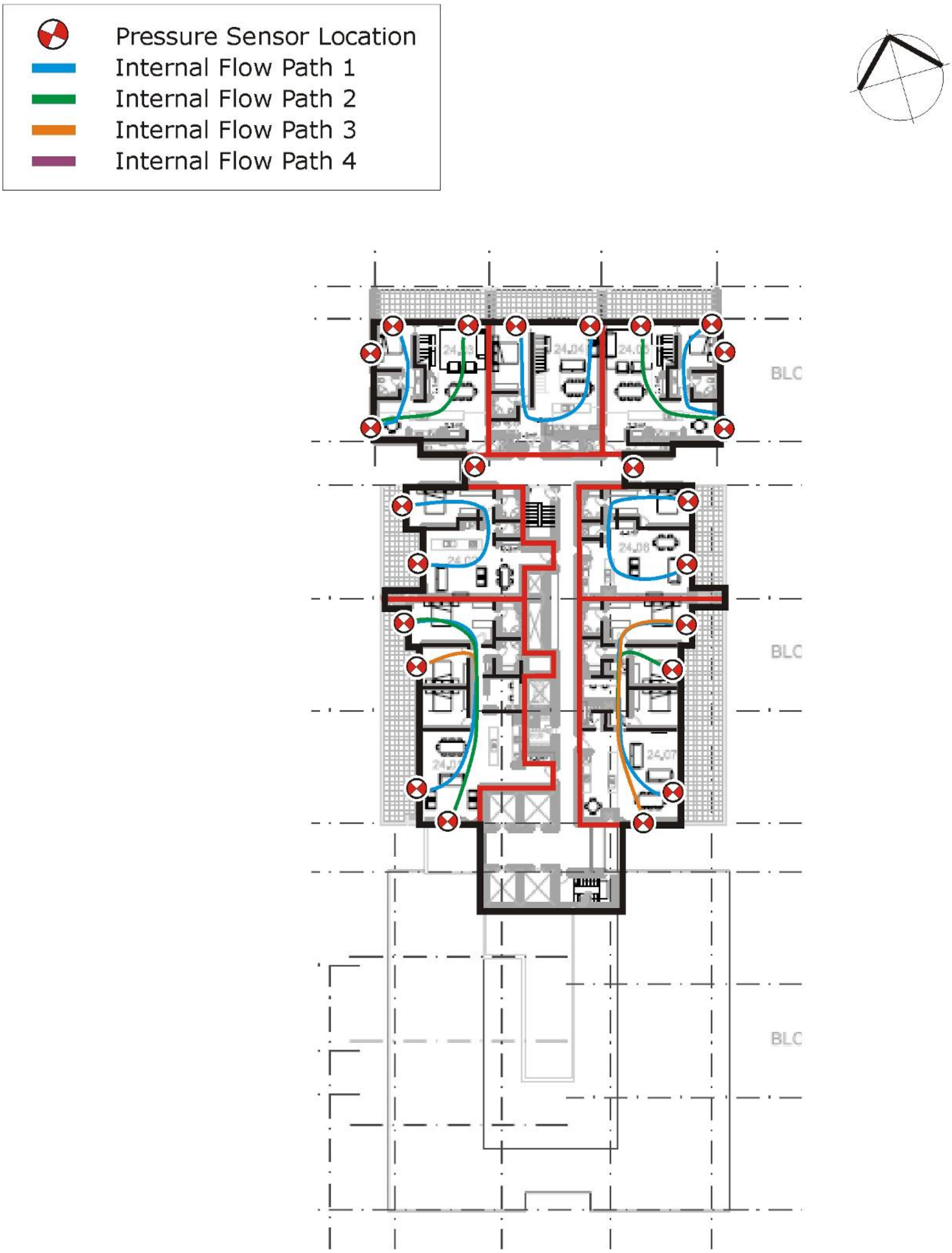
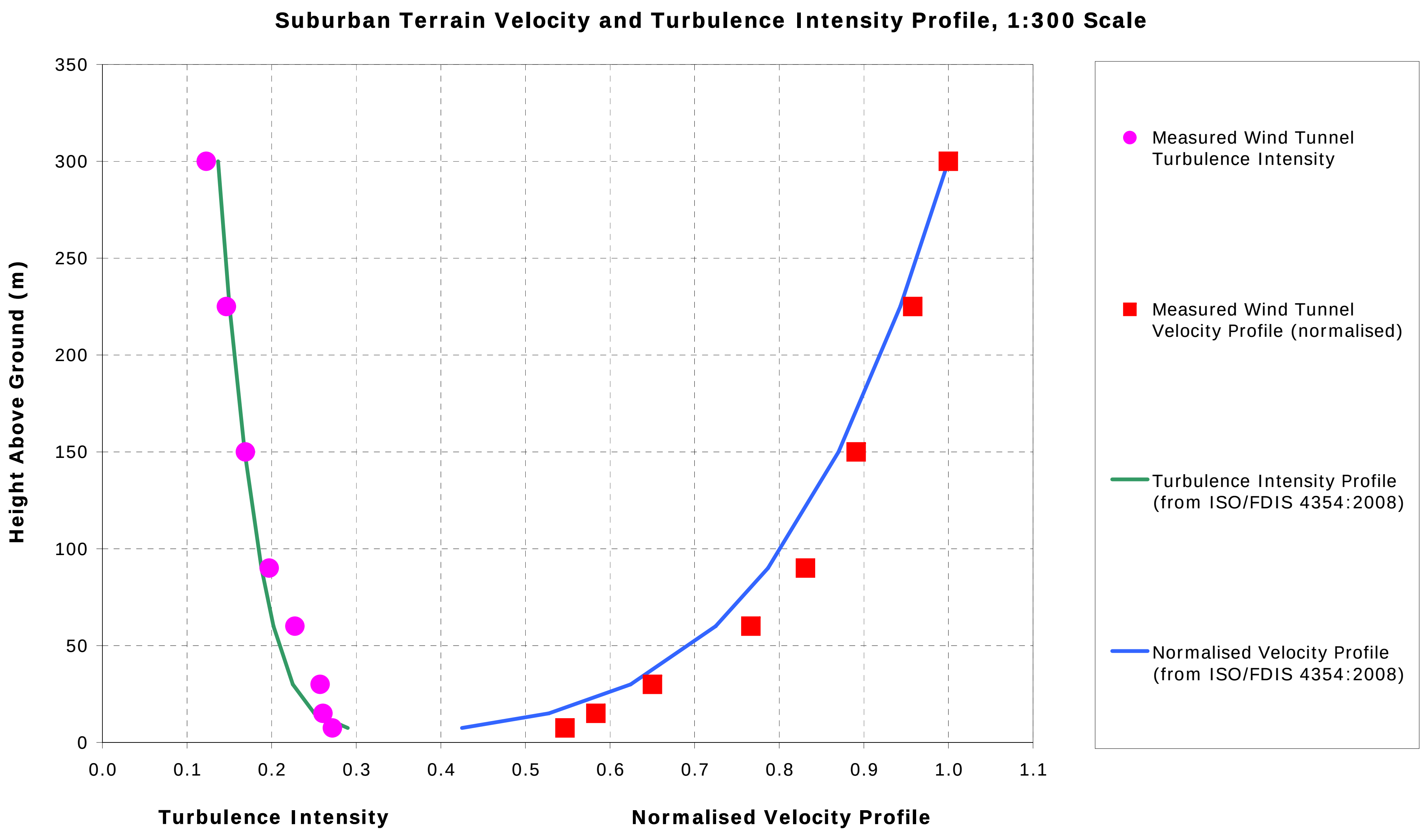


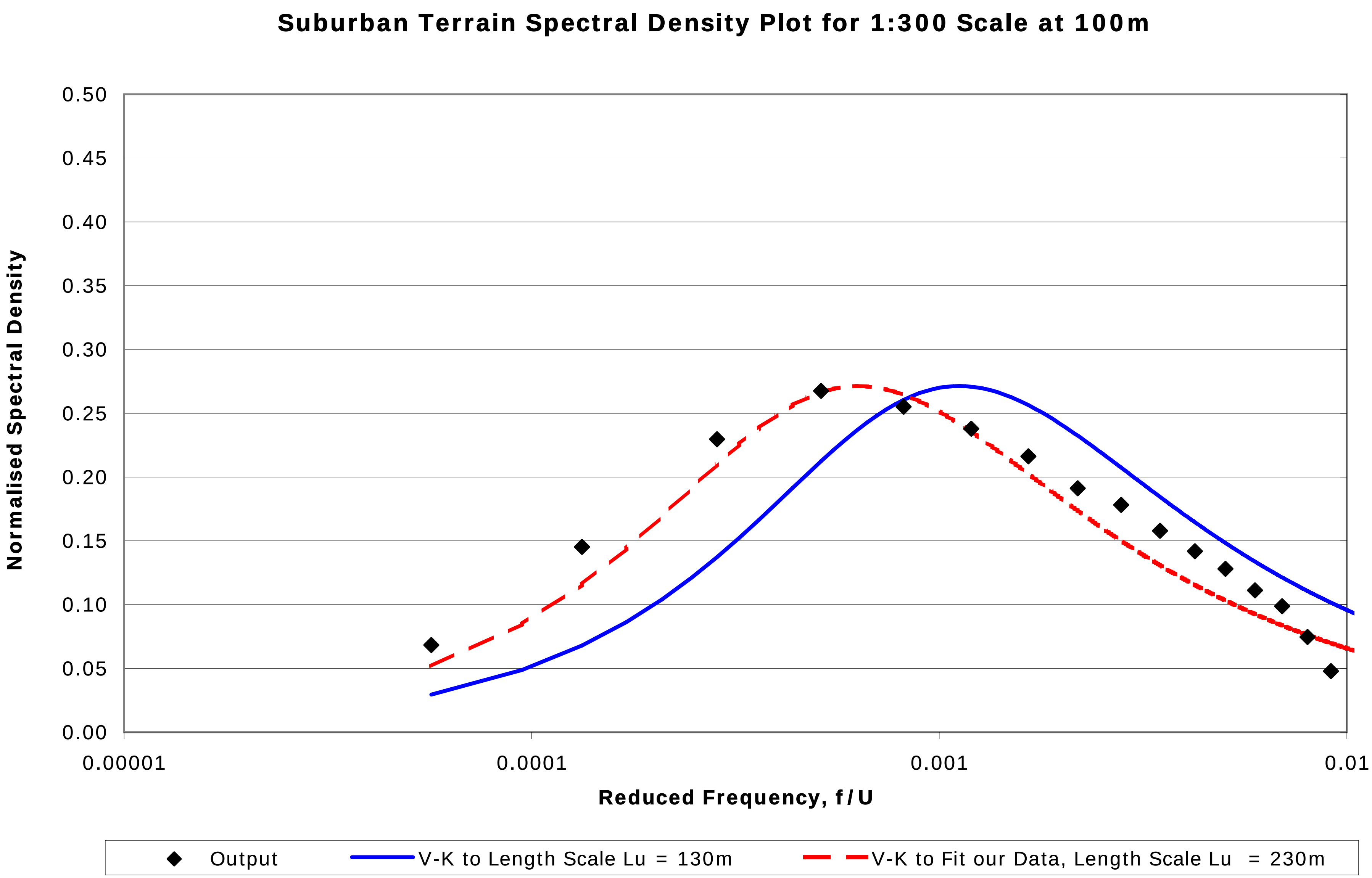
Figure C12: Internal Flow Path Diagram for Natural Ventilation - Level 24

Appendix D

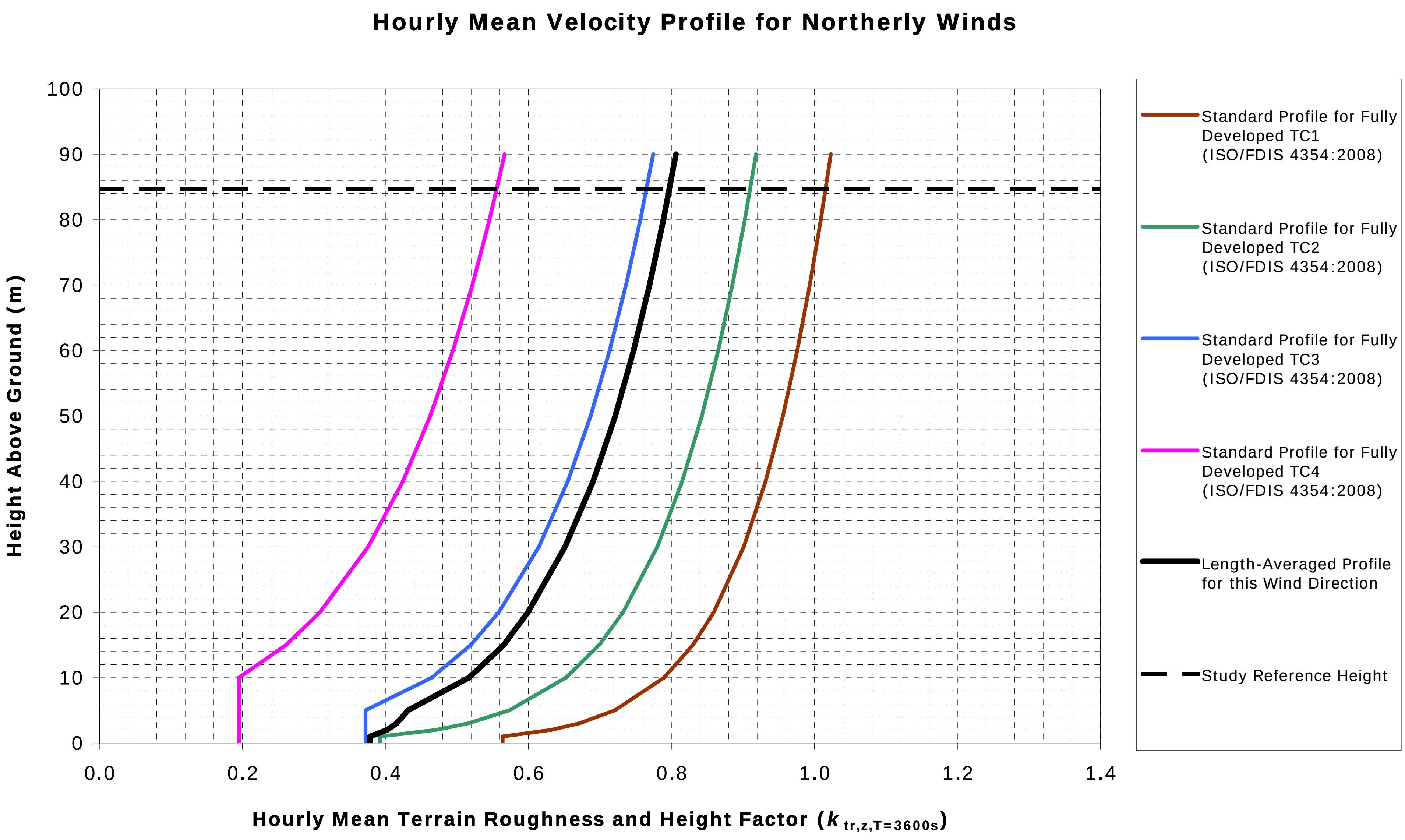
Wind Tunnel Boundary Layer Profile



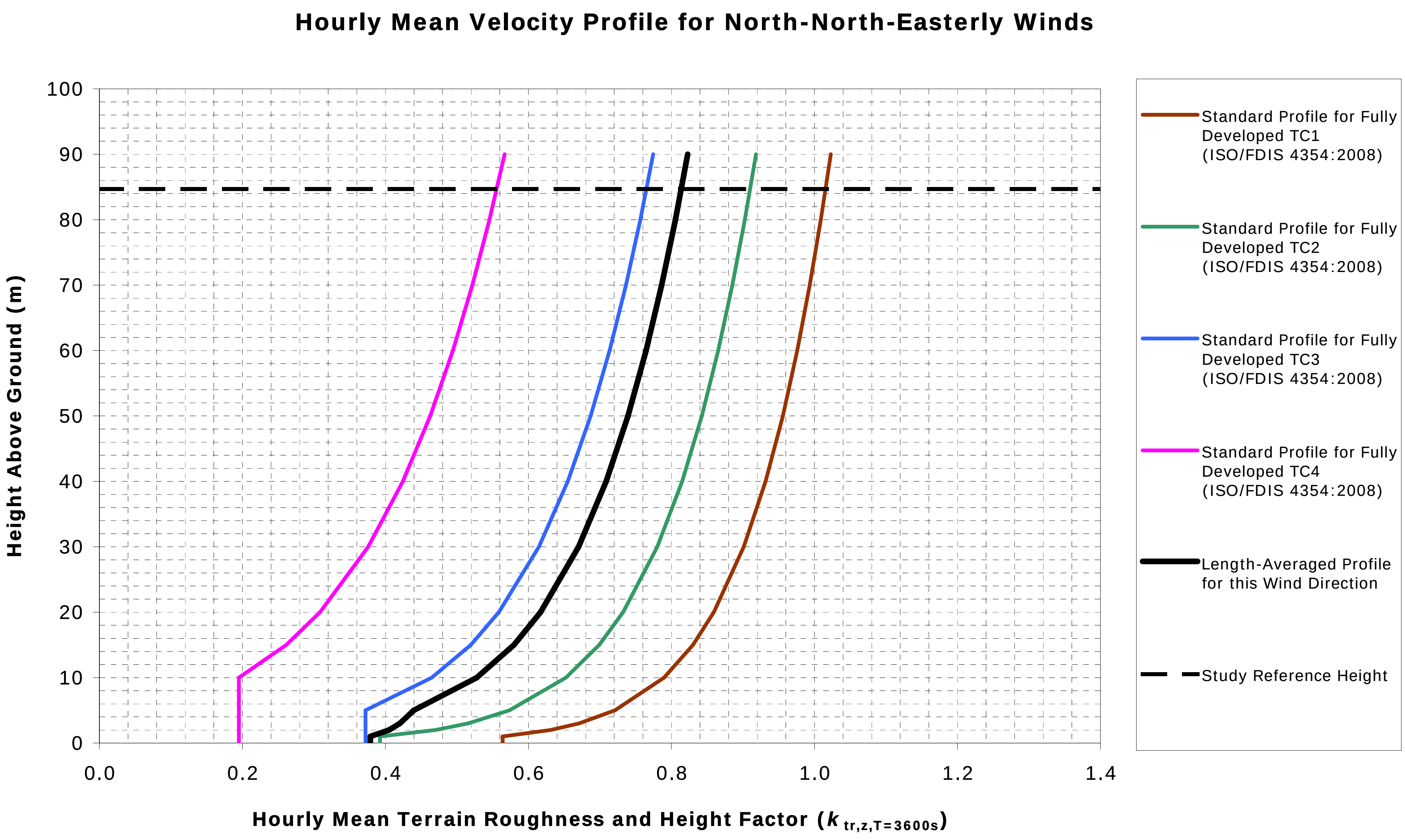
Suburban Terrain Velocity and Turbulence Intensity Profile, 1:300 Scale
Height Above Ground (m)
0
50
100
150
200
250
300
350
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
Turbulence Intensity
Normalised Velocity Profile
Measured Wind Tunnel Turbulence Intensity
Measured Wind Tunnel Velocity Profile (normalised)
Turbulence Intensity Profile (from ISO/FDIS 4354:2008)
Normalised Velocity Profile (from ISO/FDIS 4354:2008)

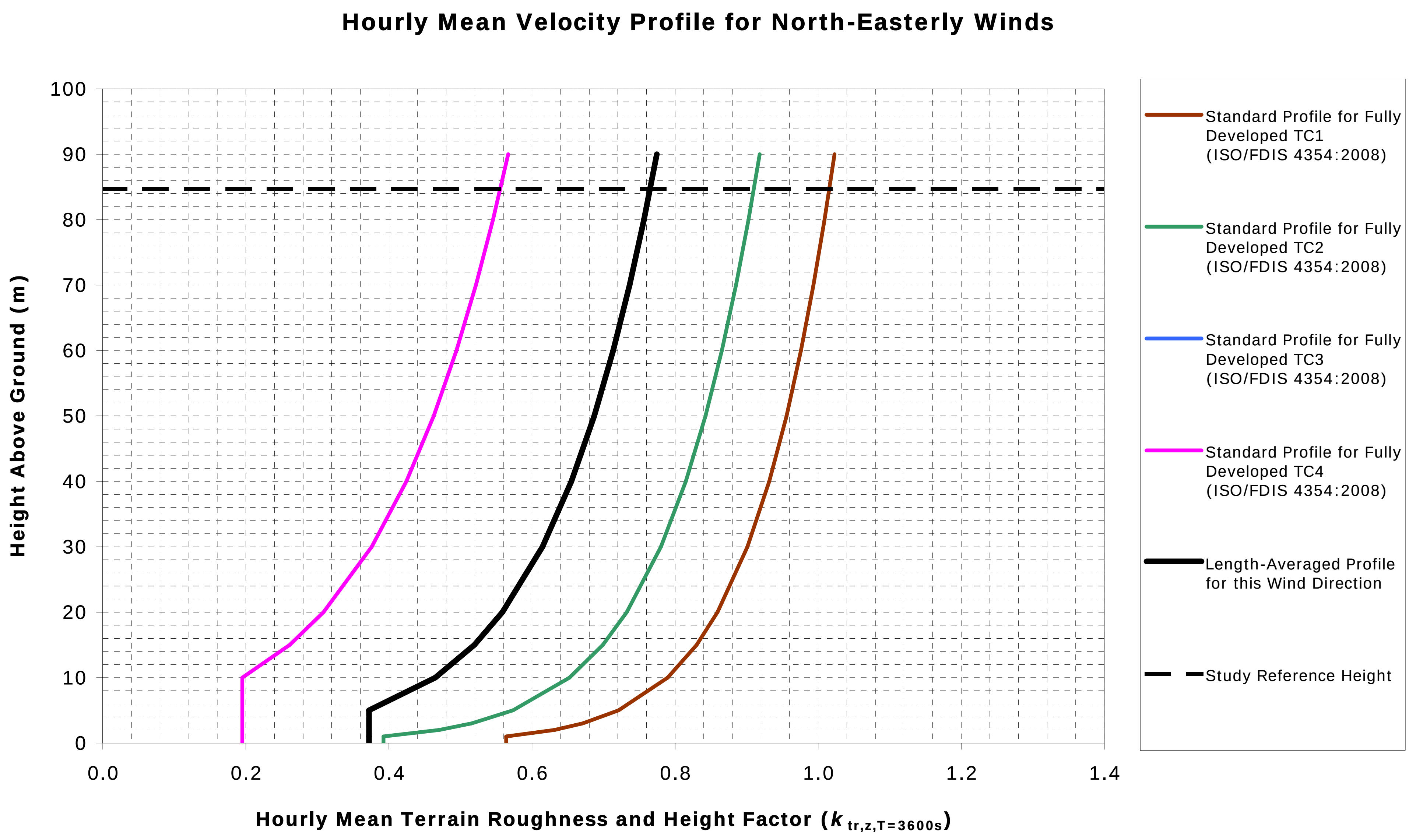


Suburban Terrain Spectral Density Plot for 1:300 Scale at 100m
Normalised Spectral Density
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00001
0.0001
0.001
0.01
Reduced Frequency, f / U
Output
V-K to Length Scale Lu = 130m
V-K to Fit our Data, Length Scale Lu = 230m

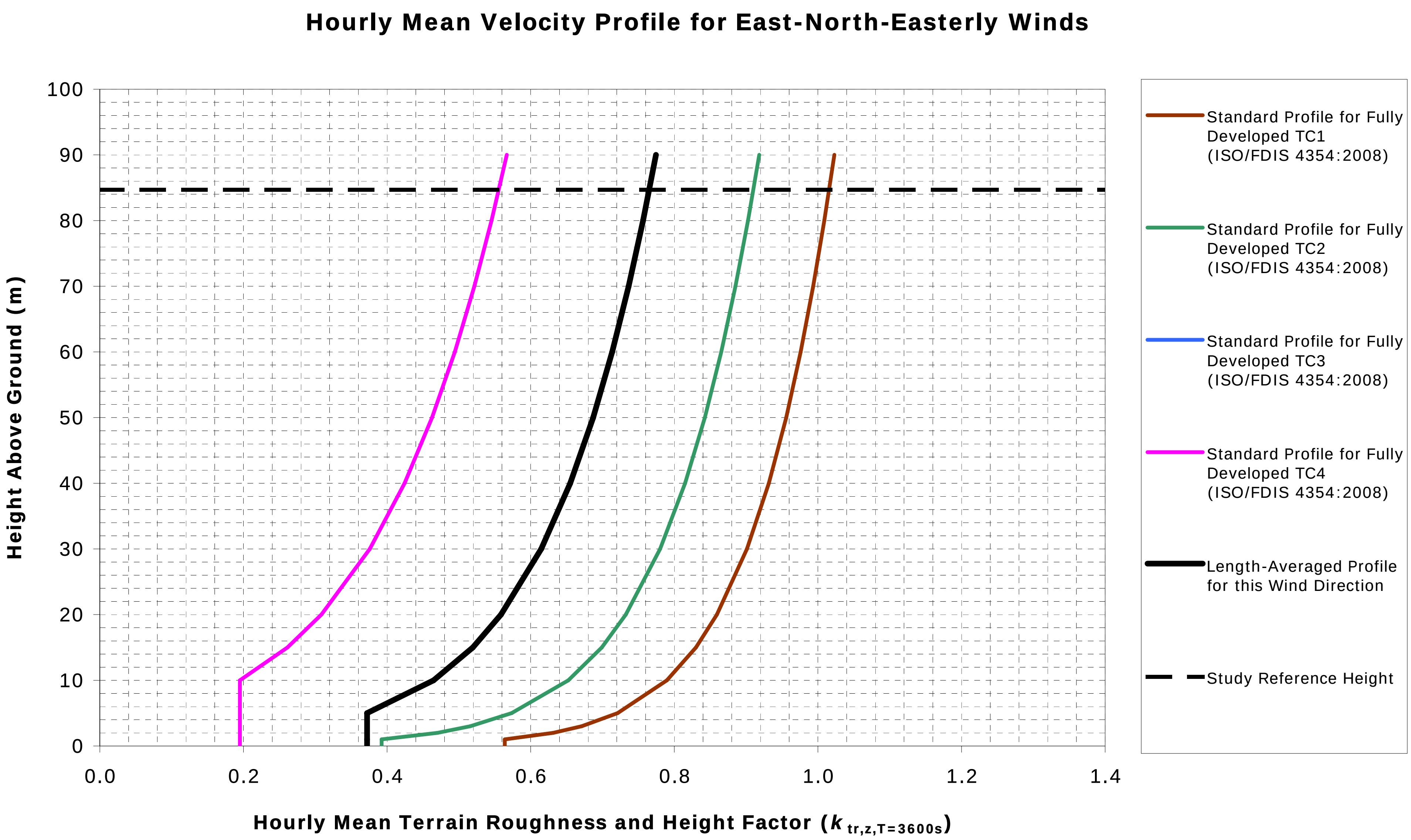


Hourly Mean Velocity Profile for Northerly Winds
Height Above Ground (m)
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
0
10
20
30
40
50
60
70
80
90
100
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height

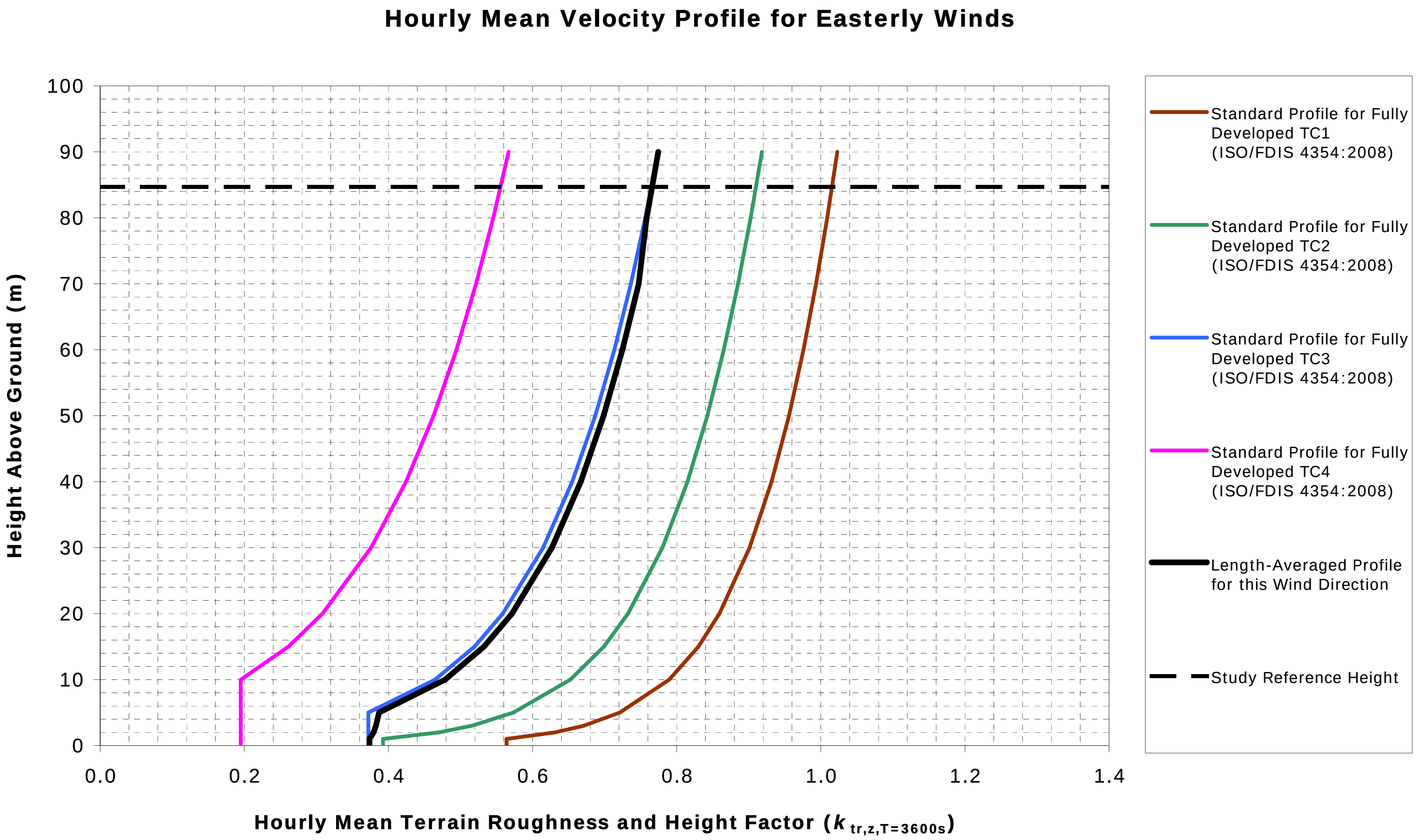

Hourly Mean Velocity Profile for North-North-Easterly Winds
Height Above Ground (m)
0
10
20
30
40
50
60
70
80
90
100
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height



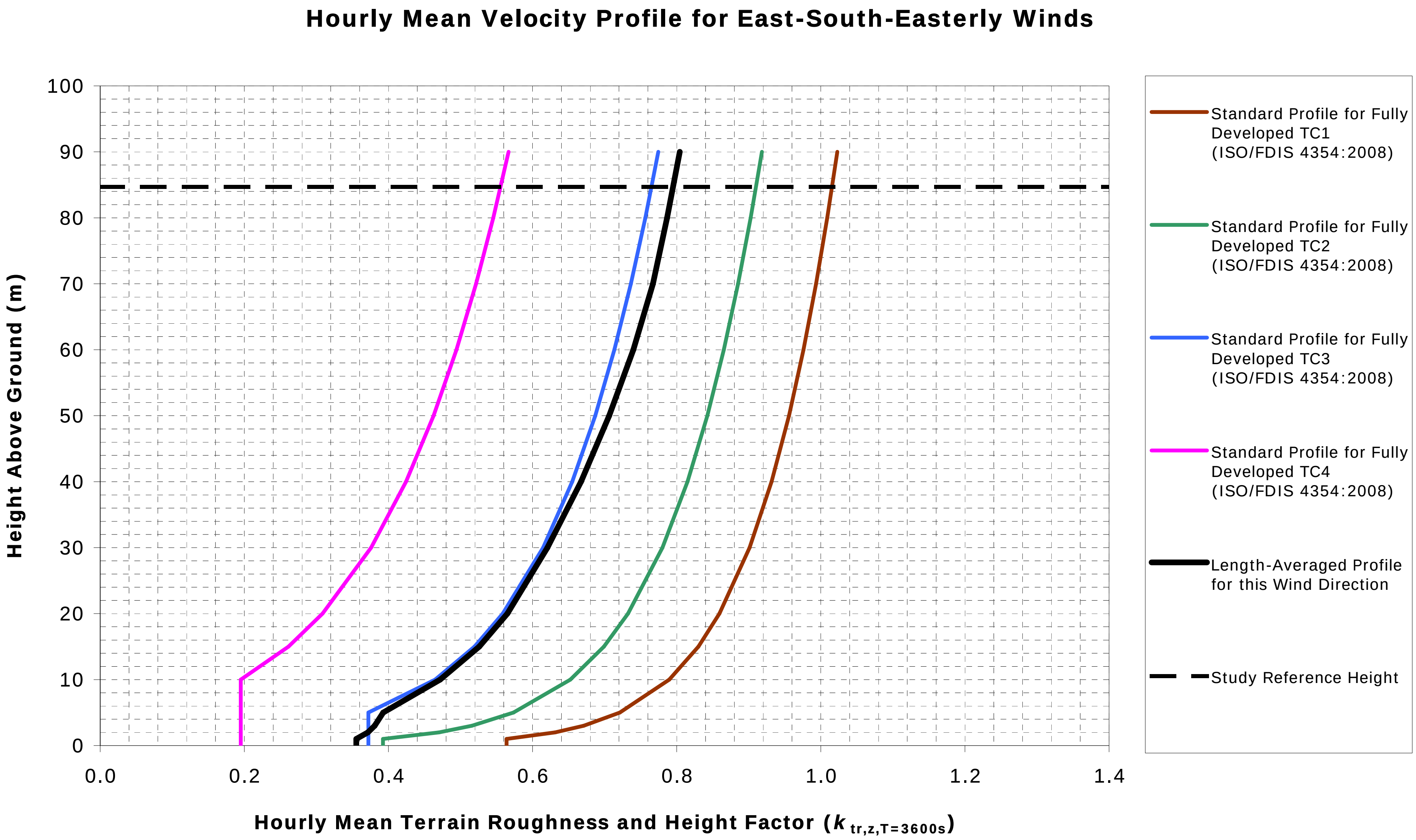
Hourly Mean Velocity Profile for North-Easterly Winds
Height Above Ground (m)
0
10
20
30
40
50
60
70
80
90
100
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height

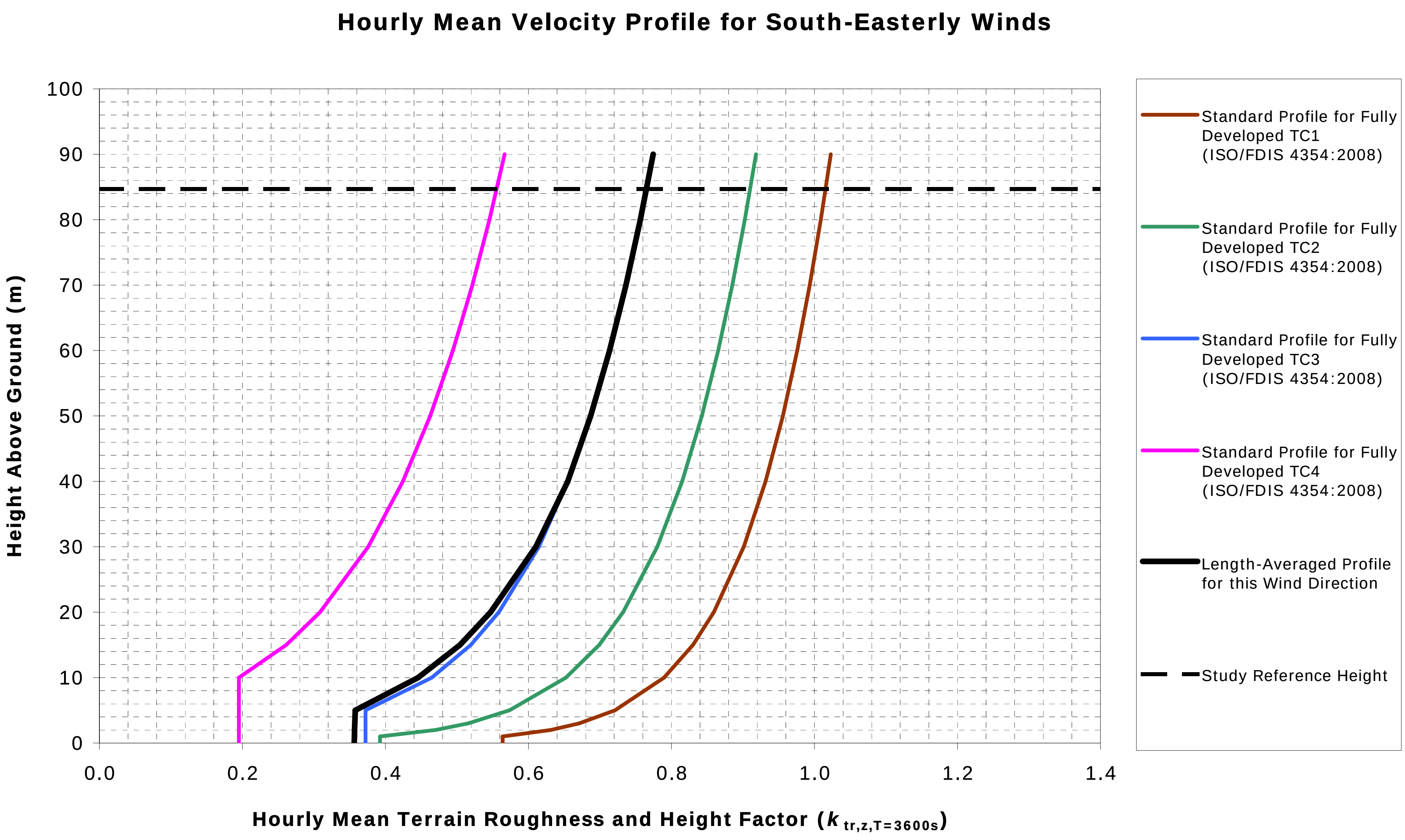


Hourly Mean Velocity Profile for East-North-Easterly Winds
Height Above Ground (m)
100
90
80
70
60
50
40
30
20
10
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height

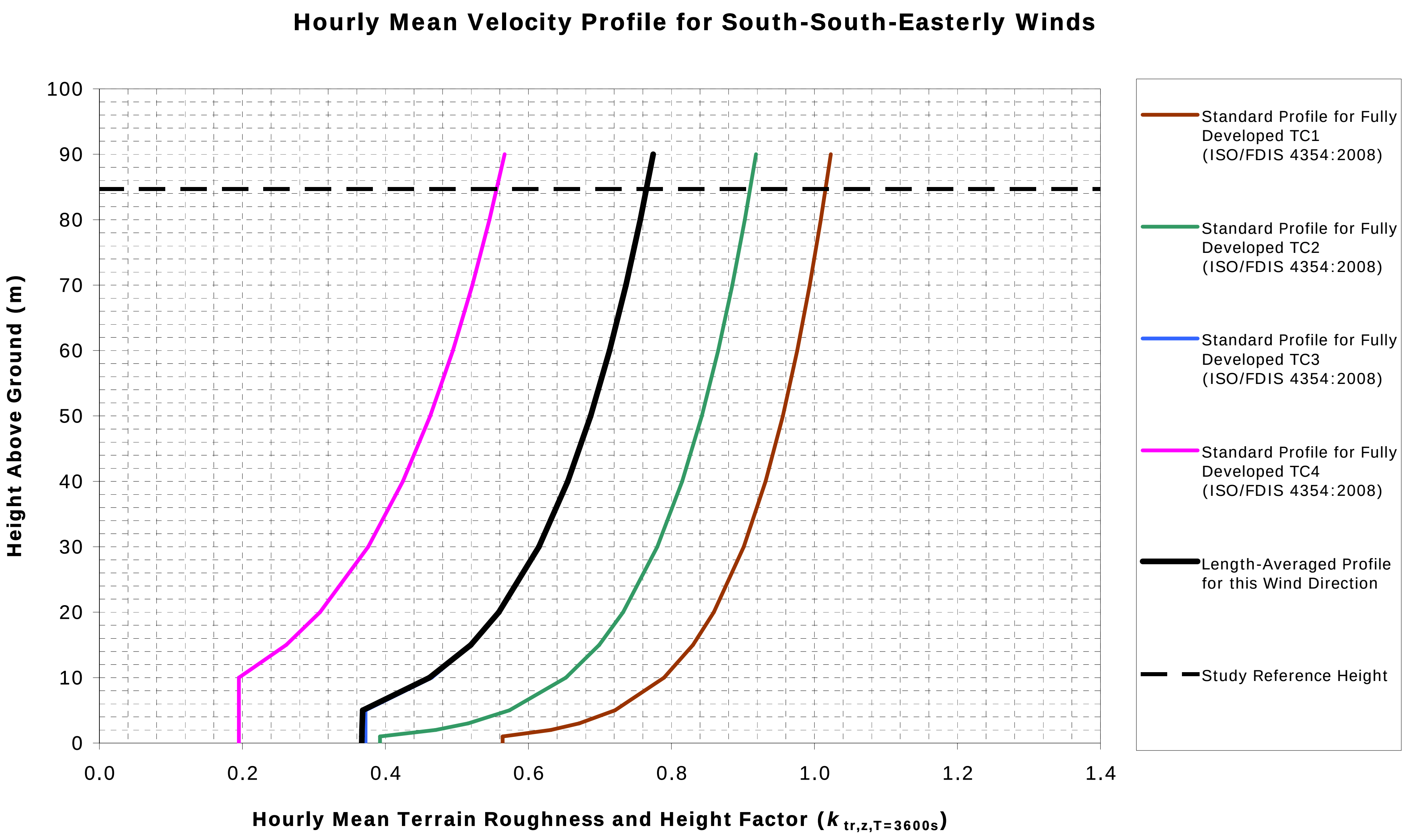


Hourly Mean Velocity Profile for Easterly Winds
Height Above Ground (m)
100
90
80
70
60
50
40
30
20
10
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height


Hourly Mean Velocity Profile for East-South-Easterly Winds
Height Above Ground (m)
100
90
80
70
60
50
40
30
20
10
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height

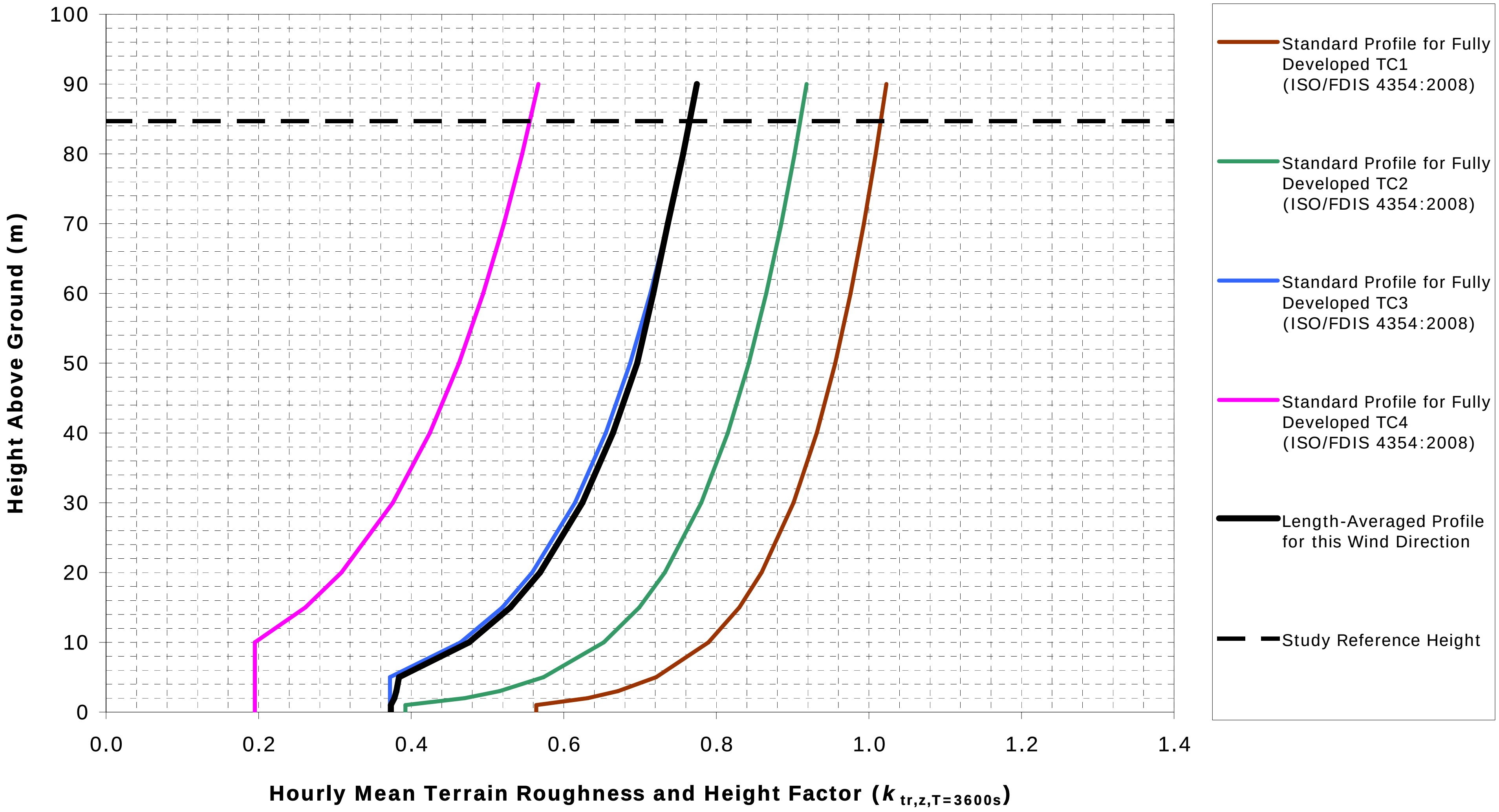


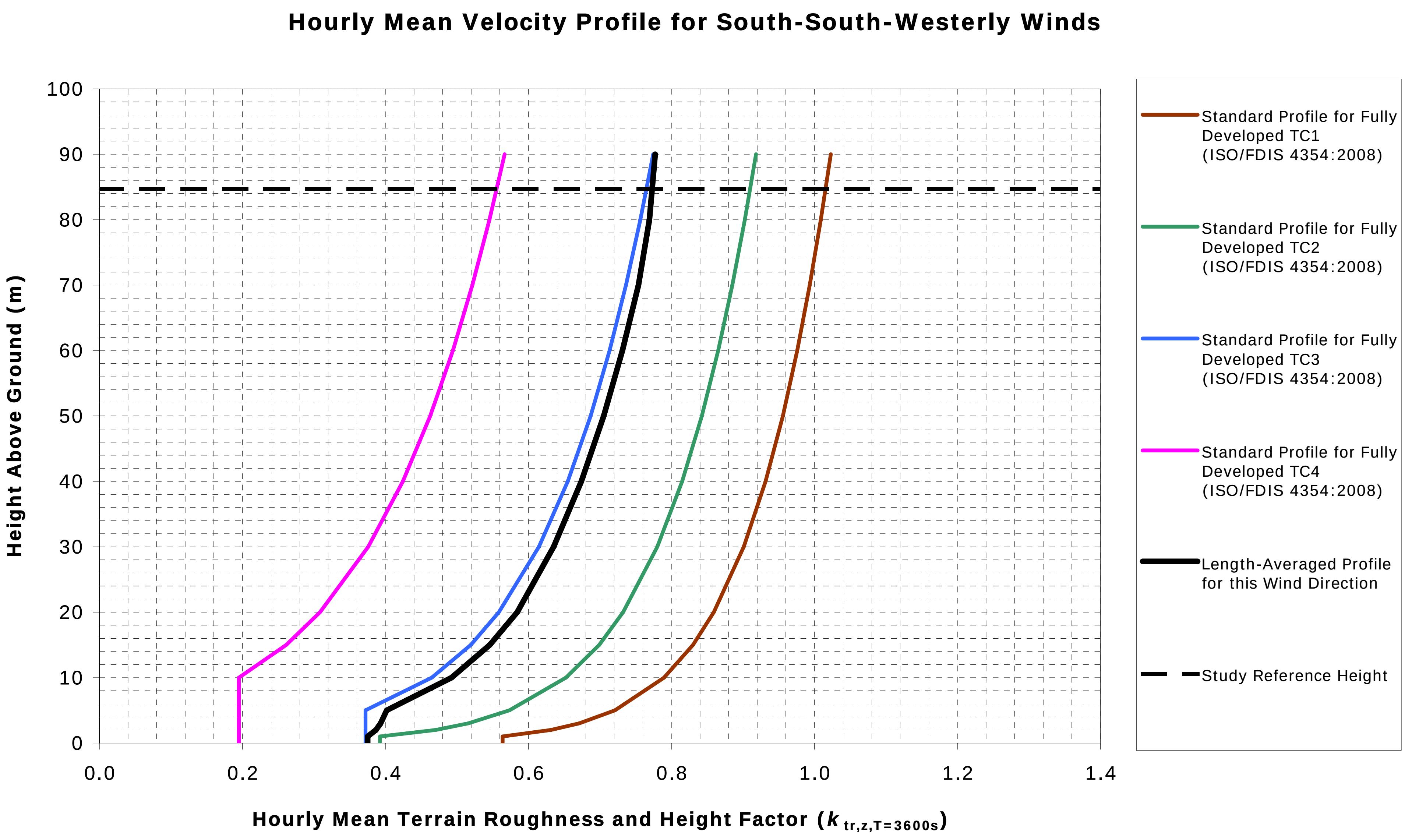
Hourly Mean Velocity Profile for South-Easterly Winds
100
90
80
70
60
50
40
30
20
10
0
Height Above Ground (m)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height



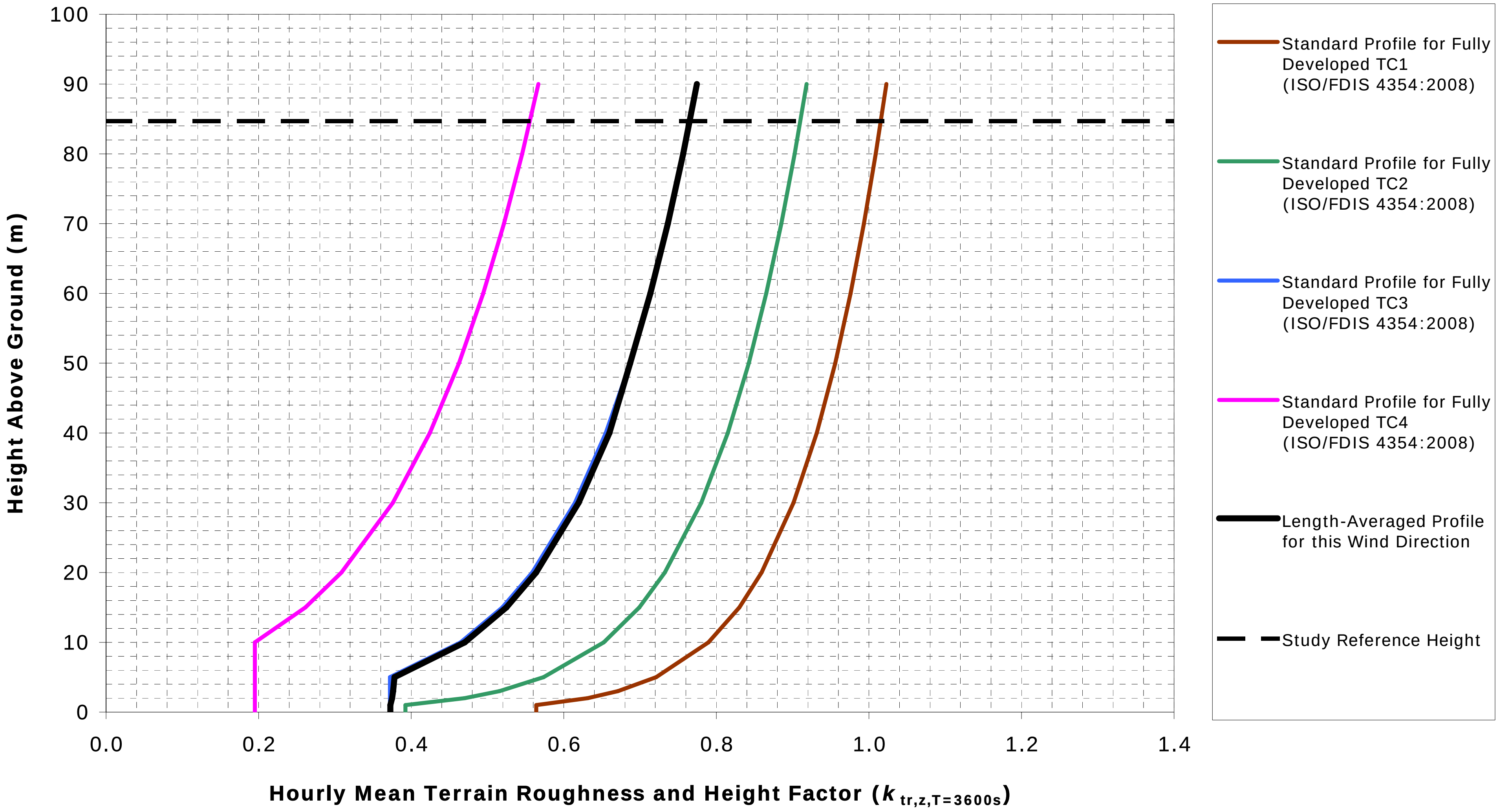
Hourly Mean Velocity Profile for South-South-Easterly Winds
Height Above Ground (m)
100
90
80
70
60
50
40
30
20
10
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height

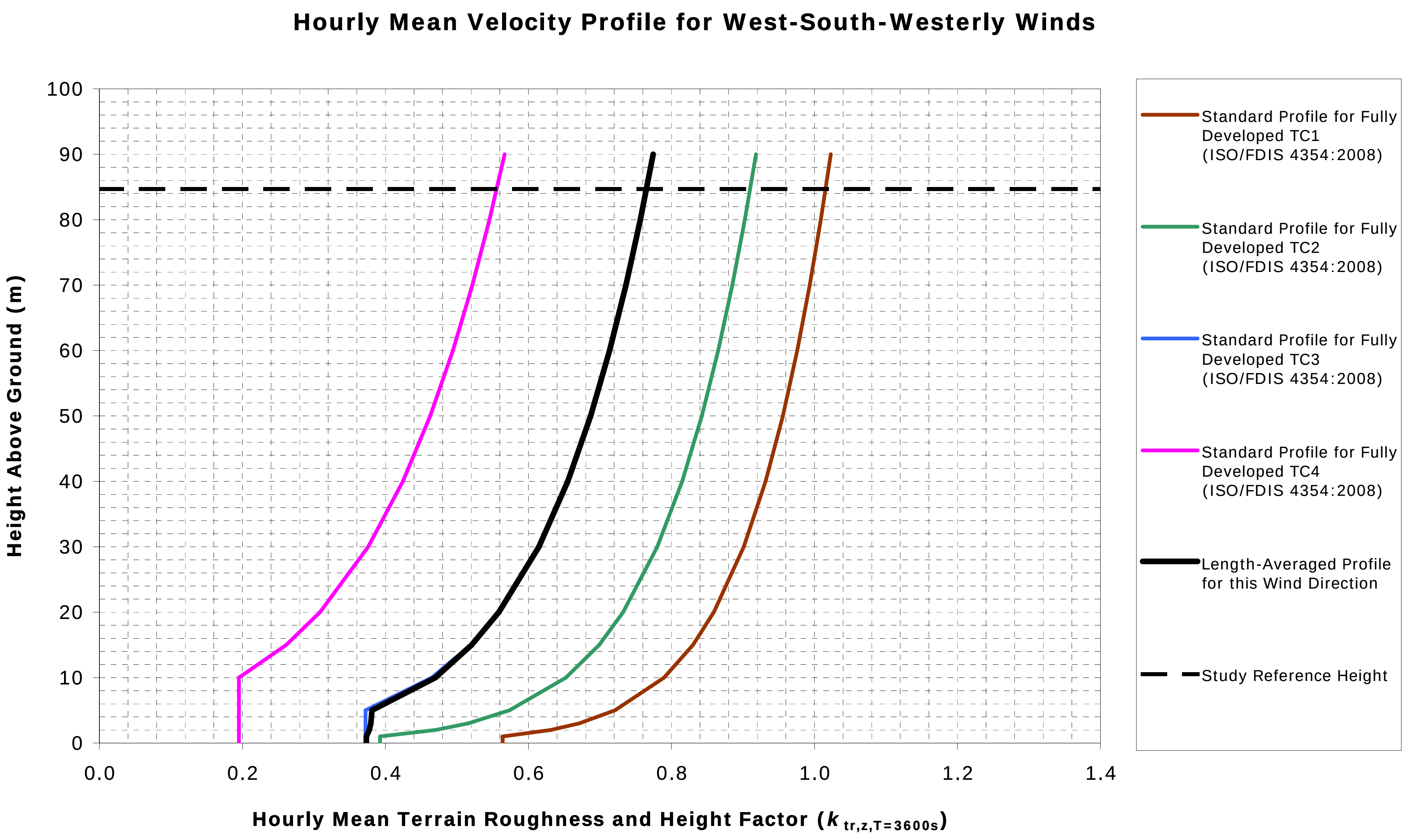
Hourly Mean Velocity Profile for Southerly Winds

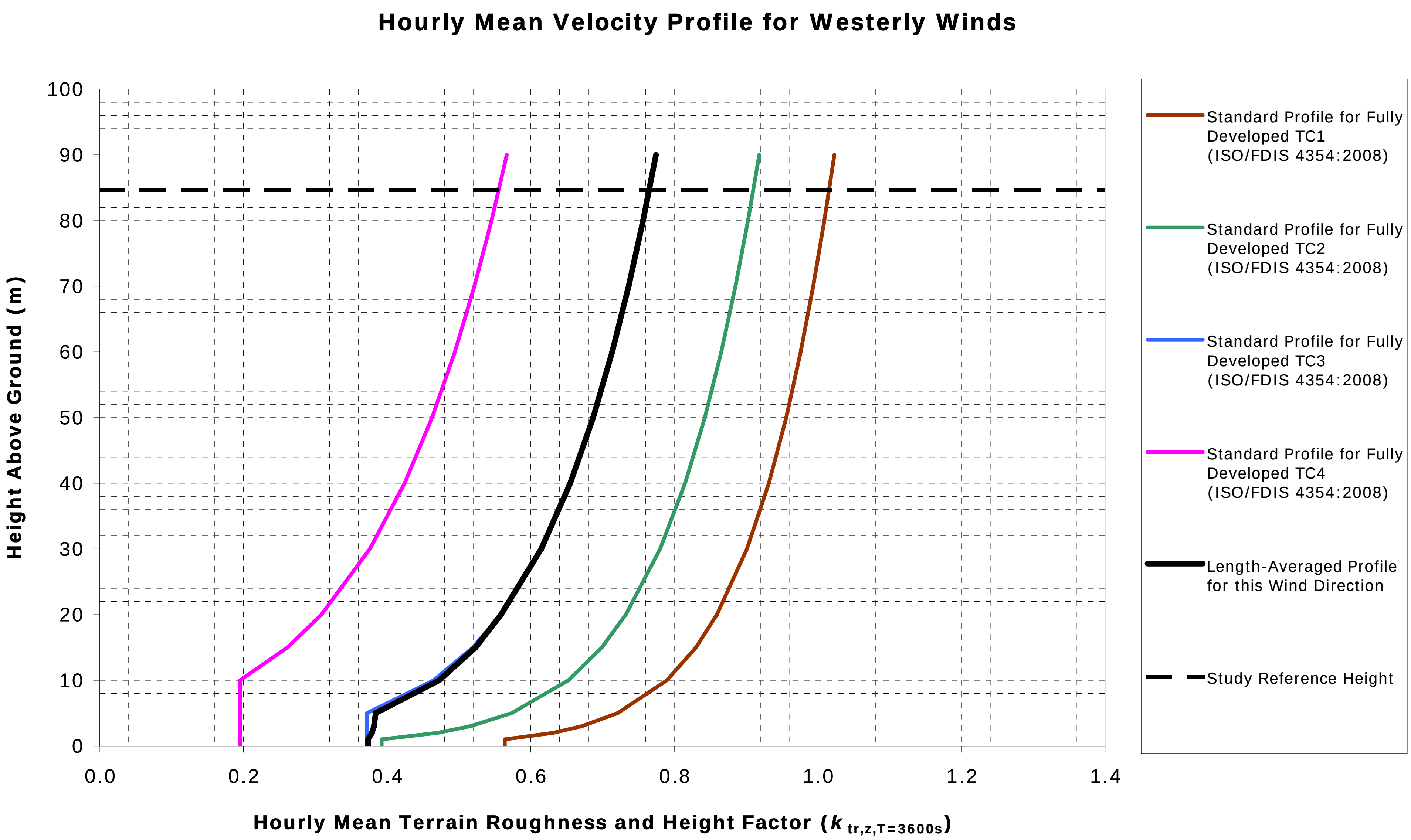


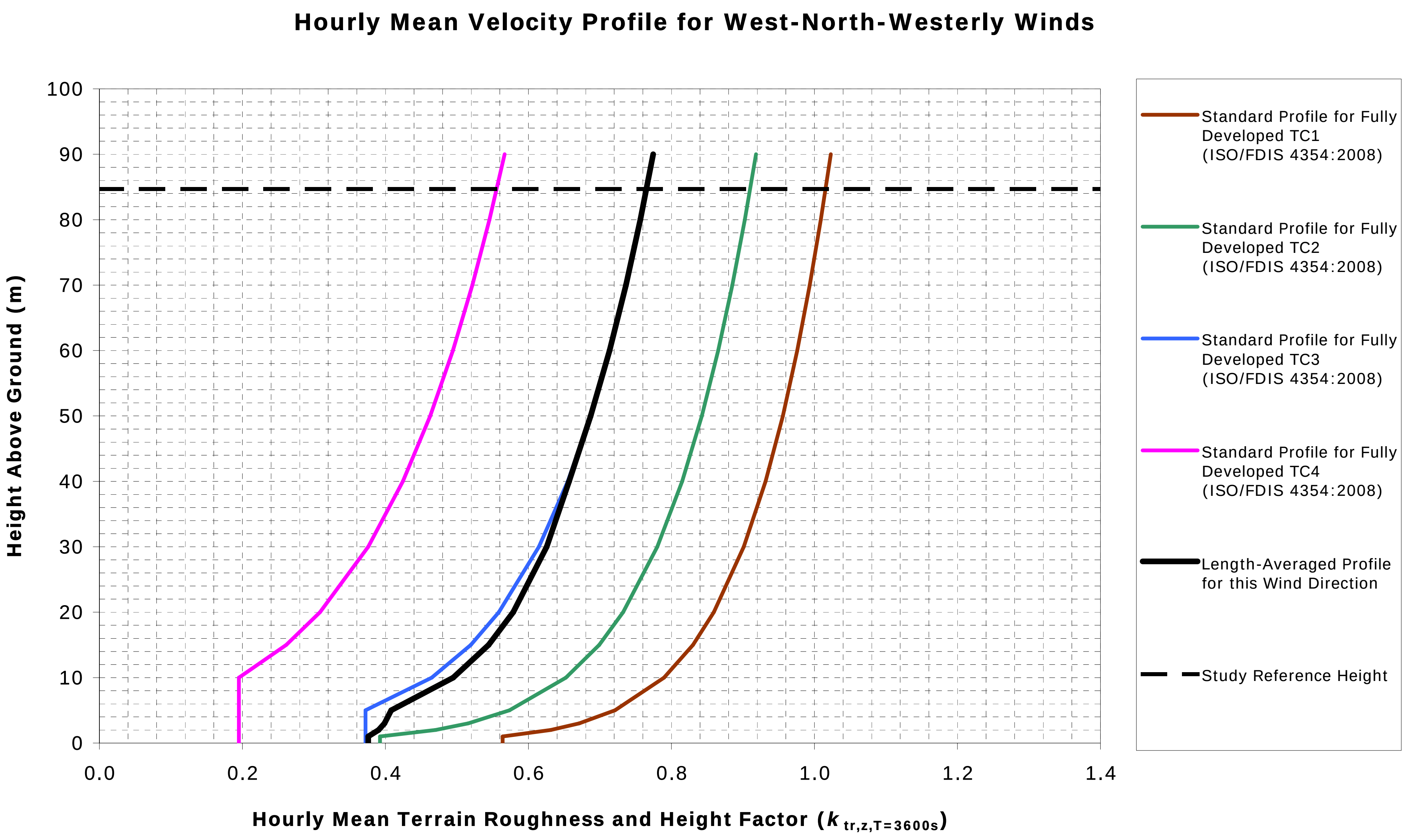

Hourly Mean Velocity Profile for South-South-Westerly Winds
100
90
80
70
60
50
40
30
20
10
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Height Above Ground (m)
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height

Hourly Mean Velocity Profile for South-Westerly Winds

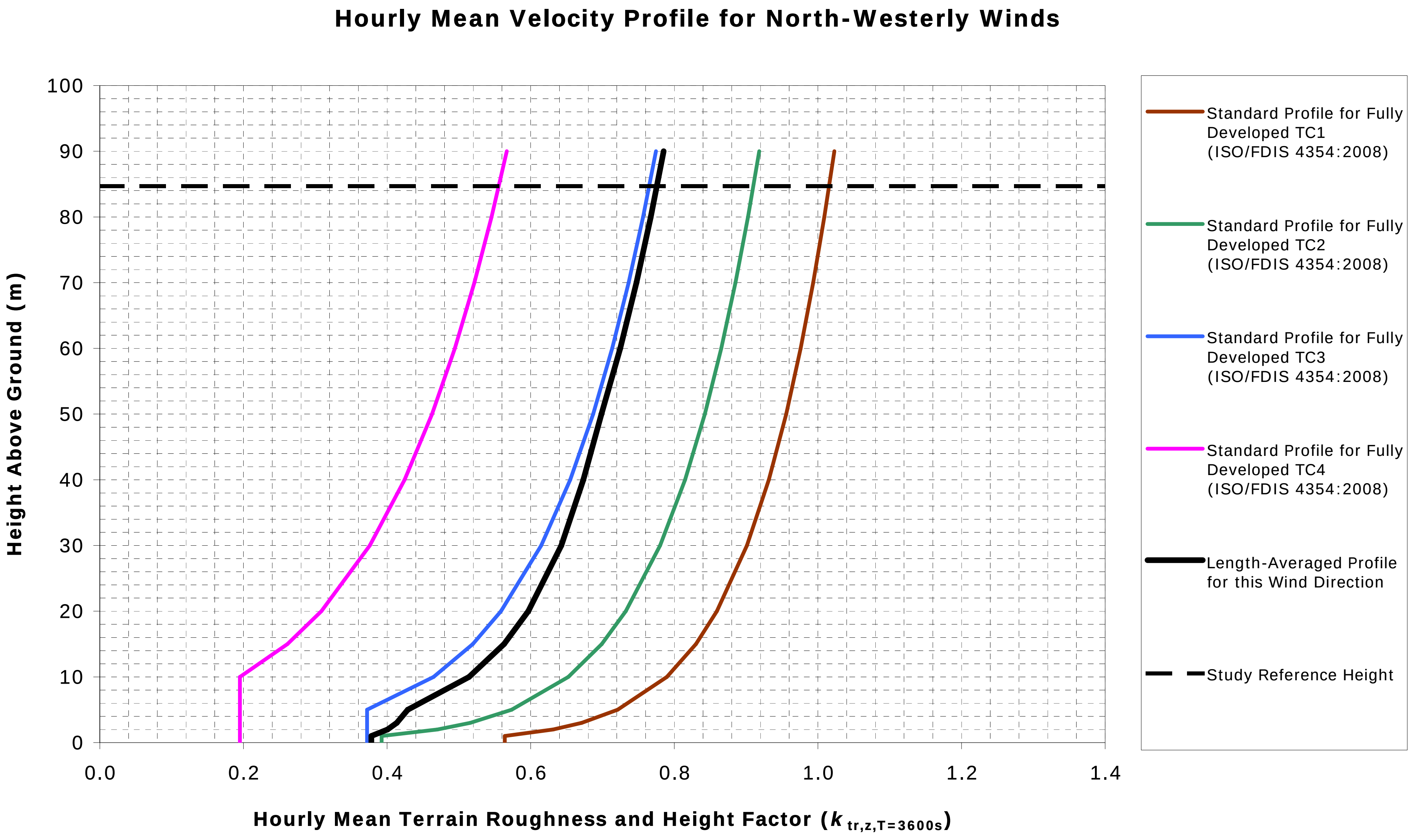



Hourly Mean Velocity Profile for West-South-Westerly Winds
Height Above Ground (m)
100
90
80
70
60
50
40
30
20
10
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height


Hourly Mean Velocity Profile for Westerly Winds
Height Above Ground (m)
100
90
80
70
60
50
40
30
20
10
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height



Hourly Mean Velocity Profile for West-North-Westerly Winds
Height Above Ground (m)
100
90
80
70
60
50
40
30
20
10
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height



Hourly Mean Velocity Profile for North-Westerly Winds
Height Above Ground (m)
0
10
20
30
40
50
60
70
80
90
100
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Hourly Mean Terrain Roughness and Height Factor ($k_{tr,z,T=3600s}$)
Standard Profile for Fully Developed TC1 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC2 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC3 (ISO/FDIS 4354:2008)
Standard Profile for Fully Developed TC4 (ISO/FDIS 4354:2008)
Length-Averaged Profile for this Wind Direction
Study Reference Height

Hourly Mean Velocity Profile for North-North-Westerly Winds