Royal Netherlands
Meteorological Institute
*Ministry of Infrastructure
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Acceptance tests of the KNMI wind vane with new encoder disk

Andrew Stepek

De Bilt, 2025| Technical report; TR 25-07

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SUMMARY

A new encoder disk has been found to replace the old one because the manufacturer of the old one will stop producing it. The KNMI wind vane with the new encoder has been tested in the laboratory, in the wind tunnel and on the test field in De Bilt. The test results show that replacing the old encoder with the new one will not cause an unacceptable change in the measurements of wind direction.

1. INTRODUCTION

The current supplier of the encoder disk of the KNMI wind vane (see figure 1) stopped making them in 2022. The stock of these spare parts should have run out in January 2025. Fortunately, a supplier of a encoder disk (E6CP-AG5C-C, manufactured by Omron) has been found which fits in the wind vane and produces the same signal. The aim of the tests described in this report is to establish if the measurements of wind direction made by the wind vane with the new encoder (new wind vane) are acceptably close to those made by the KNMI wind vane with the old encoder (Euchner PWE; old wind vane). The manufacturer's specifications of both encoders can be fouund in Annex C.

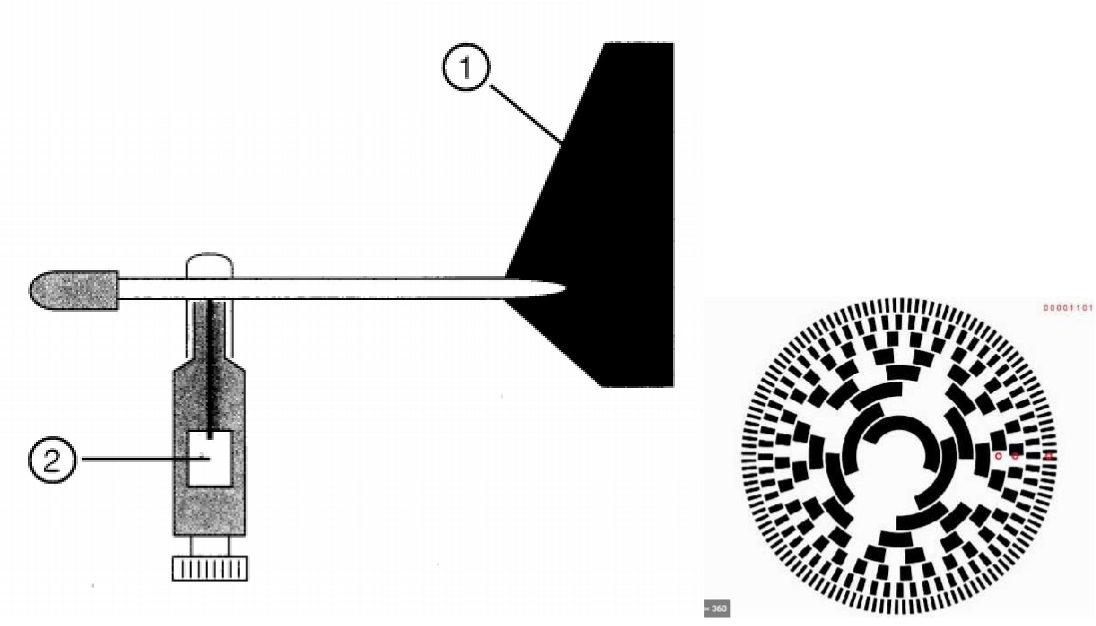

Figure 1: On the left schematic the code disk is the part labelled "2" (part "1" is called the fin) and on the right a plan view of a code disk (8 light beams shine through the 8 concentric disks to provide a unique 8 digit code for each wind direction).

2. METHODOLOGY

2.1 Laboratory Test

The new wind vane was calibrated according to the standard KNMI calibration procedure (IW-TK07-WO) where the full 360^o range of the sensor is tested.

The KNMI accuracy requirement for the wind vane in laboratory conditions is 1^o, which is the standard adjustment level (IW-IJK33-WO) used by KNMI. Another source of error is the resolution of the wind vane, which is on average 1.4^o and for an individual wind direction 0.4-2.4^o is acceptable (IW-TK07-WO). This means that 2 KNMI wind vanes with identical orientation of the fin, under laboratory conditions, could in general differ by up to 2^o (and for individual wind directions up to 2.4^o), while both vanes would be considered acceptable.

2.2 Wind Tunnel Test

In the KNMI wind tunnel, the start-up wind speed was measured on 2-3-2023 (see Appendix A). The vane was placed in the tunnel with the vane pointing towards the direction of the wind tunnel flow but with a 10^o offset. The tunnel speed was slowly increased and the speed recorded at which the vane began to move and continued to move until at least a 5^o offset was reached. This procedure was repeated 5 times for an offset on one side of the tunnel flow direction and just as often for the other side. The average of the 10 measurements was calculated for both the new and the old vane. The true start-up speed may differ from this average because the vane is large compared to the measurement volume of the KNMI wind tunnel, so the vane may disturb the wind speed measurement. However, the outside of the vanes is identical so any disturbance will be the same and comparing the start-up speeds in this way is valid.

2.3 Field Trial

From the first week of April up to the last week of November 2023 a mobile wind mast was set up on the KNMI test site in De Bilt and the new and old vanes were installed on top. The differences between the measurements of these two vanes were compared to the differences between these measurements and the measurements made by a third vane (a second old vane) on the fixed mast (16 m to the south - see photo in figure 2).

The aim of the field trial is to determine if the differences between the new and old vane are acceptable or not. One way to assess this is to take into account the distances over which the measurements are considered representative for nearby locations in practice. In practice, the wind is measured near the touchdown location at airports but for safety reasons the wind mast must be at least 90 m away from the runway. So, the differences between the 2 old vanes, separated by only 16 m, will be considered as acceptable and any differences between the new and old vanes on the same mast which are larger, will be considered unacceptable. Another way to assess the differences between the vanes comes from the standard alignment procedure of KNMI (IW-TS52-WO), which was applied when installing the wind vanes and at the end of the trial. The procedure allows for an error in the alignment of the wind vane of ±1.5^o so 2 perfect identical vanes could differ by up to 3^o due solely to the accuracy of the alignment procedure. Another source of error is the resolution of the wind vane, which is on average 1.4° but 0.4-2.4° for an individual wind direction is acceptable (IW-TK07-WO). The KNMI wind vane meets the WMO and ICAO accuracy requirements (±5°, respectively ±10°) easily, so they are not much use in assessing the differences bertween the vanes.

A KNMI cup anemometer, on the fixeed mast, measured the wind speed which is used to exclude measurement periods with very low wind speeds (< 2 m/s) where the vanes might not always work correctly.

Figure 2: Part of a panorama photo of the test site taken at 10 m height, looking north. The closest mast (the most southerly) is not used in this study, the mast in the middle is the fixed mast with a cup anemometer and an old vane. The furthest mast is the mobile mast containing both a new and old vane. All measurements were made at a height of 10 m.

The differences between the 3 vanes were sorted into 2 groups: periods with turbulent winds and with non-turbulent winds. The differences should be larger when the wind is turbulent so the new vane should show this behaviour too. Turbulence is caused by obstacles (and high surface roughness) and also by convection. On the photo of figure 2, tall trees can be seen to the west of the masts so winds from this direction will be more turbulent than from the eastern half where the obstacles are generally much lower than the measurement height. As a proxy for convection daylight hours were used and for no convection, the hours of darkness. The exact filters (1 = turbulent, 2 = non-turbulent) were:

1. (07:00:00 to 16:00:00 UTC) and (US10MIN ≥ 2.0 m/s) and[(UR10MIN ≤ 20°) or (120° < UR10MIN < 150°) or (UR10MIN > 200°)]
2. (20:00:00 to 05:00:00 UTC) and US10MIN ≥ 2.0 m/s and [(30 ≤ UR10MIN ≤ 60°) or (180° ≤ UR10MIN ≤ 200°)]

Where US stands for wind speed, UR for wind direction and 10MIN for 10 minute average (all referring to measurements from the fixed wind mast) and UTC is Coordinated Universal Time. The directions 60-120° were not used because there were too few measurements of the distance to height ratio (see Appendix B). There were too few measurements because in those directions the measurmenets are unreliable . There are low buildings very close to the wind mast and the measurement focusses automatically on them, whereas there are taller obstacles further away that affect the wind measurements more. The directions 150-180^o were not used because the distance to height ratio was was not consistently above or below 10. The directions 120-150^o were classified as having a distance to height ratio < 10 because the ratios measured for the fixed mast are consistently < 10. No ratios were available for the mobile mast for these directions (120-150^o) but the ratios for the 2 masts are in general very similar. The turbulent and non-turbulent directions also match directions with high and low roughness lengths (derived directly from wind measurements; page 51 of Wauben, 2007) except for 60-150^o, where the roughness is low because obstacles with ratios < 10 are so close (< 200 m) that the roughness length derivation does not work properly.

The signals were polled by the KNMI wind SIAM (a data logger) at a frequency of 4 Hz and the SIAM generates messages every 12 seconds containing, amongst others, the 1 minute average wind speed and direction, the 10 minute averages and standard deviations. The standard deviation of the wind direction is based on 12 second averages (calculated from instantaneous samples at 4 Hz) made every 12 seconds, while the 10 and 1 minute averages are calculated directly from the 4 Hz samples.

3. RESULTS

3.1 Laboratory Test

The new wind vane was calibrated according to the standard KNMI calibration procedure (IW-TK07-WO) and the errors found, when testing the full 360^o range of the sensor, were lower than the standard adjustment level of 1^o (IW-IJK33-WO). This means that the new wind vane is as accurate as the old one under laboratory conditions.

3.2 Wind Tunnel Test

In the KNMI wind tunnel, the start-up wind speed was measured. No measurable difference between the start-up wind speeds of the new vane and the old vane was found (both 0.8 m/s) so we can conclude that the resistance to movement of the new encoder is the same as that of the old one.

3.3 Field trail

3.3.1 Average Differences

The average difference between the 10 minute standard deviations is shown in figure 3. In absolute terms the differences are ≤ 1.0^o in turbulent wind conditions and ≤ 0.1^o in non-turbulent for each of the 3 combinations of sensors: New minus Old (N-O), both on the mobile mast; New minus the Old vane on the Fixed mast (N-OF); Old minus the Old vane on the Fixed mast (O-OF). Even in turbulent conditions, the (N-O) average difference was as small as -0.06°. The larger differences were all measured in turbulent conditions and were both -1.0° (N-OF and O-OF), which implies that the turbulent conditions experienced at the location of the fixed mast are more turbulent than at the mobile mast. It is unlikely that these larger average differences are caused by differing performances of the 3 vanes since the (N-O) bias is so small. Is an average difference of 0.1° acceptable? Yes, when compared to the resolution of the wind vane, which is 1.4°. The calculation of the 10 minute standard deviation is based on the 12 second average of the wind direction, which in turn is the average of 48 samples taken at 4Hz. Dividing the resolution of the vane by the square root of the number of samples ($\sqrt{48} = 7$) gives an effective resolution of the 12 second average of 0.2°, which is higher than the average difference of the standard deviations measured by the 2 vanes on the same wind mast. The 10 minute measurements of the standard deviation from the old vane on the fixed mast were typically between 10 and 20° so the the average differences are relatively small.

	Turbulent			Non-turbulent		
Measurement	N-O	N-OF	O-OF	N-O	N-OF	O-OF
STD	-0.06	-1.02	-0.96	0.11	-0.04	-0.15

Figure 3: Table of the average difference between the standard deviations (STD) of the 3 vanes (°) under 2 sorts of wind conditions.

Another way to assess whether the vane with the new encoder provides acceptable 10 minute standard deviations is to take into account the distances over which the measurements are considered representative for nearby locations in practice. In practice, the wind is measured near the touchdown location at airports but for safety reasons the wind mast must be at least 90 m away from the runway. The distance between the 2 wind masts of the field trial is only 16 m, so the (O-OF) differennce of -1.0° is acceptable in practice and since the difference (N-OF) is the same size, it must also be acceptable.

The average difference between the 10 minute averages and between the 1 minute averages is difficult to assess for 2 of the 3 combinations of vanes because the monthly bias shows a steady trend throughout the duration of the test period: the difference between the 2 vanes on the same mast shows no trend. The trends for the 10 minute averages during non-turbulent wind conditions are shown in figure 4 (the 1 minute averages show the same trend, of course). The trend shows that the difference (mobile mast vane – fixed mast vane) increased so the mobile mast measurements became more veered than the fixed mast measurements. This implies that the horizontal beam at the top of one of the towers (upon which the wind sensors are mounted) has gradually turned. Either the beam on the mobile mast has backed 3° or the beam on the fixed mast has veered 3°.

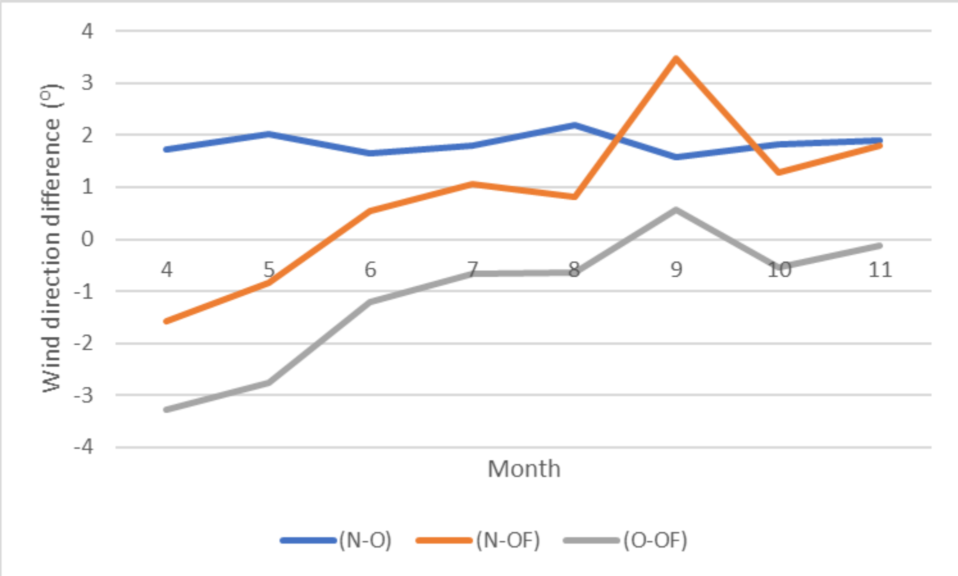

Figure 4: trend in monthly average of the differences between the 10 minute average wind directions of the 3 vanes under non-turbulent wind conditions

In December 2023 (2 weeks after the trial period ended) the mobile mast was inspected to see if the trend in the bias of the differences between the vanes on the 2 masts could be explained by a change in the orientation of the vanes with respect to true north. One vane had to be turned 2.5^{o} and the other 3.0^{o} to line them up with true north again but the difference between 2.5 and 3.0^{o} is insignificant. The vanes were aligned with true north at the start of the trial so the conclusion is that the horizontal beam on the mobile mast gradually backed 2.5 to 3.0 during the course of the field trial period. On the 1st of February 2024 the orientation of the vane on the fixed mast was checked and it was turned 1.5^{o} to reallign it with true north but the alignment procedure has an accuracy of ±1.5^{o} so any change in alignment since the start of the trial is insignificant and can not explain the observed trend in the differences. Furthermore, this gradual change in alignment has not been observed in the decades that KNMI uses these fixed masts at tens of locations. The horizontal beam at the top of the fixed mast has therfore not turned and the trend is due to the mobile mast. KNMI has only one mobile mast and has had it for less than 10 years. The large monthly average of the difference between the new vane on the mobile mast and the old one on the fixed mast (3.5^{o} in September) can be explained by the gradual turning of the beam on the mobile mast and it is not due to the new encoder.

The average (N-O) difference for the whole measurement period for both 10 minute and 1 minute averages is 1.7^{o} in turbulent wind conditions and 2.0^{o} in non-turbulent conditions. These figures are reliable because there was no trend in the monthly biases because these two vanes are mounted on the same mast (the mobile mast). The procedure for lining up the north of the vanes to true north has an accuracy of ±1.5^{o}, so differences between 2 vanes up to 3^{o} are acceptable.

3.3.2 Standard Deviations

The 8 month standard deviations of the differences between the 3 vanes for the 3 measurement parameters can be found in the table of figure 5 and in figure 6 there are examples of the time series and frequency distribution plots (all of the frequency plots looked Gaussian). The standard deviations of the differences between the two vanes on the mobile mast and the one on the fixed mast (reference) are similar for all 3 parameters but the standard deviations involving the new vane (N-OF) are either the same or larger than the difference between the 2 old vanes (O-OF) and never smaller. The extent to which (N-OF) is larger than (O-OF) is small for STD (the 10 minute standard deviation of 12 second average wind directions) and for UR10MIN: only 0.0-0.3°. However, for UR1MIN (N-OF) is 0.6° larger in turbulent conditions and 0.4° in non-turbulent. If these differences were significant, it would imply that the new vane responds differently to changes in the wind direction compared to the old vane but an intrinsic accuracy of the KNMI wind vane of ± 1.2° (conform IW-TK07-WO) is acceptable, so differences between 2 vanes ≤ 2.4° are insignificant.

Since the monthly average of the differences of the 10 (UR10MIN) and 1 minute (UR1MIN) average wind direction between the 2 masts shows a trend of a bit more than 3°, the standard deviation of these 2 measurement parameters will be too large by about 2° because the standard deviation of a Gaussian distribution covers 2/3 of the data population. However, the trend is based on the bias of all differences throughout the whole period, while the standard deviations are based on differences measured during turbulent or non-turbulent conditions. Such periods are not evenly spread throughout the whole measurement period (see figure 6), so to correct the standard deviations for the trend in the bias, less than 2° should be subtracted. The correction should be 1.7° or less because that is the smallest standard deviation involving the old vane on the fixed mast (OF in figure 5) and standard deviations can not be negative. It should be less than 1.7° because the corrected smallest standard deviation would otherwise become 0.0° and unrealistic for 10 minute average wind directions. The correction should be at least 0.6° lower than 1.7° to ensure that the smallest corrected standard deviation (0.6°) is higher than the smallest standard deviation of (N-O), which is 0.5°, since (N-O) is not corrupted by the trend and 2 vanes on the same mast should have a smaller standard deviation than 2 vanes on separate masts: so a correction of 1.1° (= 1.7° - 0.6°) is a logical choice. This means that if there was no trend in the bias, the standard deviations of the (O-OF) differences of UR10MIN would be 2.3° (= 3.4° – 1.1°) for turbulent conditions and 0.6° (1.7° – 1.1°) for non-turbulent. For UR1MIN the (O-OF) differences would be 7.8° (= 8.9° – 1.1°) and 3.0° (= 4.1° - 1.1°) respectively. Using the same argument as before (for the average differences), the standard deviations of the (O-OF) differences should be acceptable because the distance separating the 2 masts is small compared to the area that wind measurements are assumed to be representative for in aviation practice. In that case the standard deviations of the (N-O) differences for UR10MIN and UR1MIN in the table are acceptable because they are smaller.

	Turbulent			Non-turbulent		
Measurement	N-O	N-OF	O-OF	N-O	N-OF	O-OF
STD	1.3	3.6	3.3	0.6	1.6	1.6
UR10MIN	1.2	3.6	3.4	0.5	1.8	1.7
UR1MIN	4.7	9.5	8.9	2.1	4.5	4.1

Figure 5: Table of the standard deviations of the differences between the 3 vanes (^{o}) for the 3 measurement parameters under 2 sorts of wind conditions, i.e. the standard deviation of the differences in STD, in UR10MIN and in UR1MIN. Differences involving OF have not been corrected for the trend.

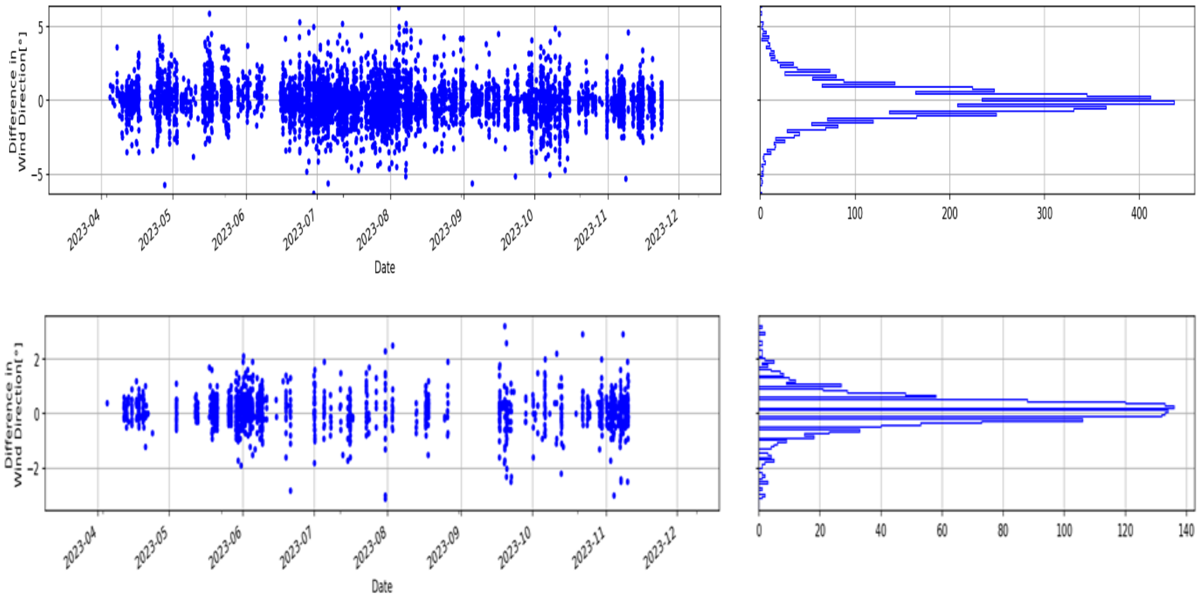

Figure 6: Time series (left) and frequency distributions (right) of the (N-O) differences of the 10 minute standard deviation of wind direction (STD) for turbulent (top) and non-turbulent (bottom) wind conditions. NB: the y-axis scales are not the same.

The standard deviation of the differences between the STD (10 minute standard deviation of wind direction) of one vane and that of another, is not as easy to understand as the standard deviation of the differences between the UR10MIN/UR1MIN (average wind direction of one vane and that of another. STD is a measure of the spread of the 12 second average wind directions around the average value so the standard deviation of the STD differences is the spread of the differences between the spread of the 12 second averages. So, it is a measure of the differing response of the 2 vanes to turbulence. From figure 3 in section 3.3.1, there is effectively no difference (only 0.06^{o} or less) in the distribution of the (N-O) STD differences, so on average the STD of the 2 vanes is identical. The standard deviation of the STD differences is not zero and that means that the STD of the one vane is sometimes higher and sometimes lower than the other. The spread of these differences is greater in turbulent conditions (standard deviation of 1.3^{o}) than in non-turbulent conditions (0.6^{o}), as one would expect. If we compare the spread of the differences to the acceptable error of the alignment procedure (up to 3^{o}), it is plain that the differing response of the new vane compared to the other will not introduce larger errors than are already accepted in practice. Also, these (N-O) values from the table (figure 5) are a factor 2-3 smaller than the

(O-OF) values, which means that any errors introduced by the new vane will be smaller than the errors already acceptable in aviation practice and due to the physical separation of the wind mast and the airport runway.

4. CONCLUSIONS

There is no measurable difference between the start-up wind speeds of the KNMI wind vane with the new encoder and the one with the old one when measured in the KNMI wind tunnel. This means that the frictional resistance of the new encoder is the same as that of the old one.

During the field trial, the the average difference between the 10 minute standard deviations was in absolute terms 1.0^o or less in turbulent wind conditions and 0.1^o or less in non-turbulent and for each of the 3 combinations of wind vanes. This difference is what one would expect and indicates that the wind vane with the new encoder has the same correct dynamic response to changes in the wind conditions as the existing wind vane. Is the average difference of 0.1^o acceptable? Yes, when compared to the resolution of the wind vane, which is 1.4^o for instantaneous measurements and 0.2^o for the 12 second averages used to calculate the 10 minute standard deviation. In practice, the wind is measured near the touchdown location at airports but for safety reasons the wind mast must be at least 90 m away from the runway. The distance between the 2 wind masts of the field trial is only 16 m, so the (O-OF) differences are acceptable in practice and since the (N-OF) average difference is the same size (-1.0^o), it must also be acceptable. The 10 minute measurements of the standard deviation from the old vane on the fixed mast were typically between 10 and 20^o, so the average difference between the standard deviations of the new and old vane are relatively small compared to the typical size of the standard deviation. The average of the (N-O) differences for both 10 minute and 1 minute average wind direction (UR10MIN, respectively UR1MIN) is 1.7^o in turbulent wind conditions and 2.0^o in non-turbulent conditions. The procedure for lining up the north of the vanes to true north has on an accuracy of ±1.5, so the average difference between 2 vanes of up to 3^o is acceptable.

The standard deviations of the differences of the measurements made by the vanes (1 new and 1 old) on the mobile mast compared to the old vane on the fixed mast (reference) are similar but the standard deviation of the measurement differences involving the new vane is either the same or larger than the standard deviation of the differences between the 2 old vanes and never smaller. If these differences were significant, it would imply that the new vane responds differently to changes in the wind direction compared to the old vane but this is not the case. The intrinsic accuracy of the KNMI wind vane is between 1 and 2^o, so differences between 2 vanes less than 3^o are insignificant. The standard deviations in turbulent conditions are twice those in non-turbulent conditions for the difference between all 3 pairs of vanes and for all measurement parameters analysed. This implies that the wind vane with the new encoder reacts to turbulence as one would expect and, in a quantitative sense, as much as the vane with the existing part does.

The trend-corrected standard deviations of the (O-OF) differences for average wind directions should be acceptable because the distance separating the 2 masts is small compared to the area that wind measurements are assumed to be representative for in aviation practice. In that case the standard deviations of the (N-O) differences for average wind speeds (UR10MIN and UR1MIN) are acceptable.

The standard deviation of the STD differences is not zero and that means that the STD (10 minute standard deviation of wind direction) of the one vane is sometimes higher and sometimes lower than the other. The spread of these differences is greater in turbulent conditions (standard deviation of STD differences of 1.3^{o}) than in non-turbulent conditions (0.6^{o}), as one would expect. If we compare the spread of the differences to the acceptable error of the allignment procedure (up to 3^{o}), it is plain that the differing response of the new vane compared to the other will not introduce larger errors than are already accepted in practice. Also, these (N-O) values (from the table in figure 5) are a factor 2-3 smaller than the (O-OF) values, which means that any errors introduced by the new vane will be smaller than the errors already acceptable in aviation practice and due to the physical separation of the wind mast and the airport runway.

In short, the KNMI wind vane with the new part (encoder disk from Omron) will not negatively impact the quality of the measurements of wind direction when it replaces the KNMI wind vane with the current encoder disk.

References

IW-IJK33-WO, KNMI wind vane calibration procedure. https://confluence.knmi.nl/display/WWO/Kalibratielaboratorium+en+Sensor+specialisten?preview=/108728048/148145562/IW-TK07-WO%20Windvanen%20kalibreren%20Rev%205.0.pdf

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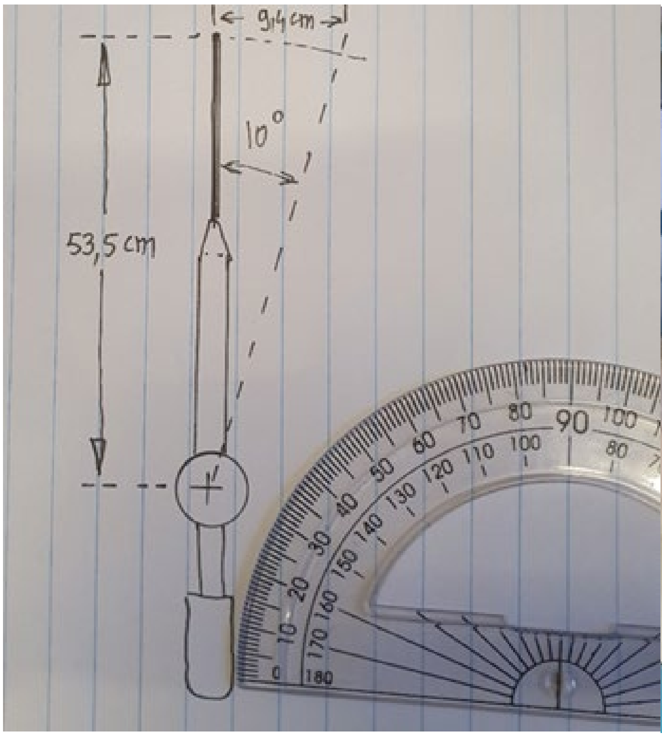
Wauben, 2007. Wind Tunnel and Field Test of Three 2D Sonic Anemometers, KNMI Technical Report, TR296.

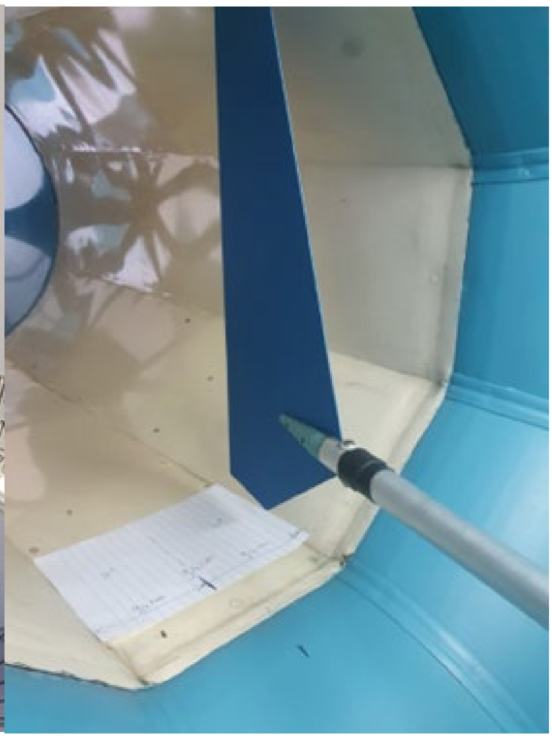
Appendix A

Start-up speed measurements (vane turns from 10 to 5⁰ away from the tunnel wind direction) made on 2-3-2023 in the KNMI wind tunnel of the KNMI wind vane with new and old encoder by Jos Verbeek.

responsie windvanen van 10° naar 5°		
	01.00.524-060	01.00.524-109
	nieuwe decoder	oude decoder
	m/s	
Vaanblad links	0,8	0,8
	0,8	0,7
	0,8	0,7
	0,7	0,8
	0,7	0,8
Gemiddeld	**0,8**	**0,8**
Vaanblad rechts	0,9	0,8
	0,9	0,7
	0,8	0,7
	0,7	0,8
	0,8	0,9
Gemiddeld	**0,8**	**0,8**

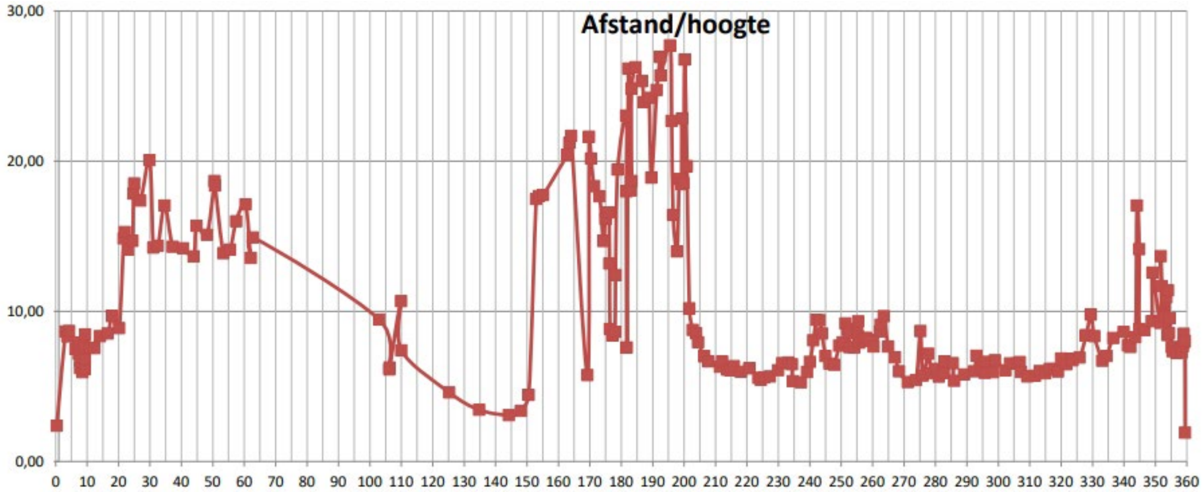
Where “vaanblad links” means vane fin positioned to the left of the tunnel air flow and “vaanblad rechts” means to the right. Also, “gemiddeld” means average.



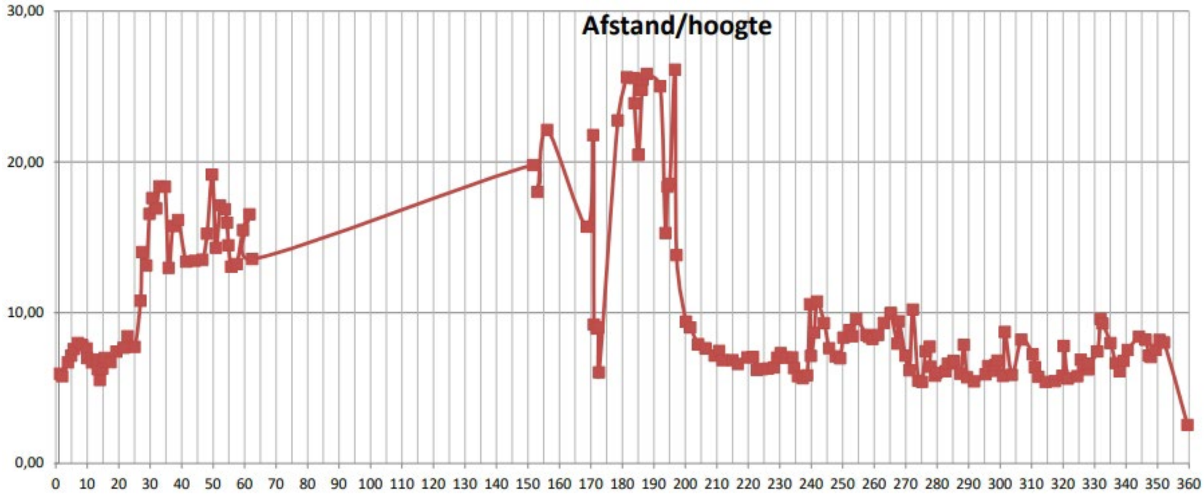



Wickes

Appendix B



Obstacle distance/height (y-axis) against wind direction (x-axis) as seen from the fixed wind mast on 20230322



Obstacle distance/height (y-axis) against wind direction (x-axis) as seen from mobile wind mast on 20230322

Appendix C

EUCHNER

Absolut-Winkelgeber

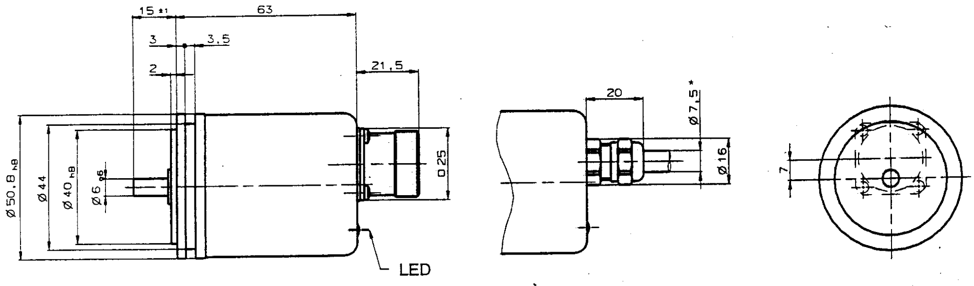
Bauform PWE

CE

- Zentrierbund 40 mm
- Schrittzahl pro Umdrehung max. 256
- Gray-, Gray-Exzeß- und Dual-Code
- Ausgabefrequenz max. 300 000 Hz
- EMV-sichere Gegentakt-Ausgangsschaltung überlastgeschützt

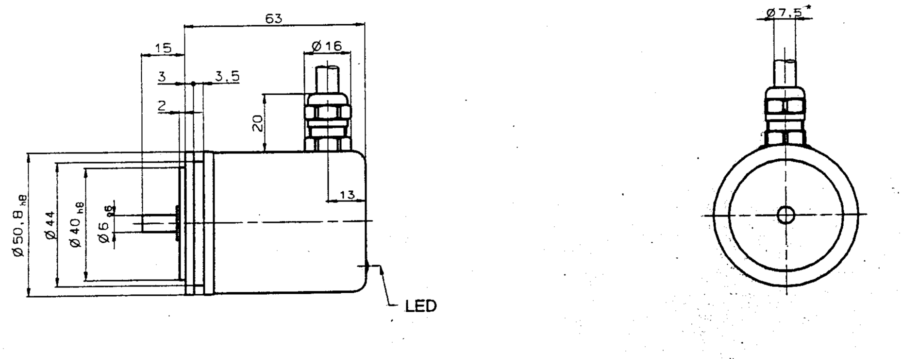
Abmessungen

Ausführung PWE Steckverbinder / Leitung axial



* Zulässige Biegeradien der Anschlußleitung siehe Seite 74

Ausführung PWE Leitung radial



Bestell- / Typentabelle

Zubehör siehe Seite 74-77

Typen	Dreh-richtung	Ausgabe-code	Schritt-zahl	Meß-schritt	Lesetakt Ausgang 1	Parität Ausgang 8	Ausgänge	Anschluß	Best.Nr.
PWE	cw	Dual	8	45°	18,0	gerade	8	Leitung radial 2 m	072 351
			12	30°					072 352
		Gray	256	1,406°	–	–			072 353

Auf Anfrage

- Andere Schrittzahlen
- Ausgabecode BCD, kündenspezifisch
- Drehrichtung counterclockwise (ccw)
- Leitung axial
- Steckverbinder axial oder radial

Technische Änderungen vorbehalten 08/97

Bauform PWE

Zentrierbund 40 mm

Technische Daten

Meßtechnische Parameter	**Wert**	**Einheit**
Schrittzahl pro Umdrehung	max. 256	
Meßschritt (Auflösung) α	min. 1,406	°
Fehlergrenze	α/2	°
Teilungscode	Gray, Gray-Exzeß, Dual	
Ausgabecode	Gray, Gray-Exzeß, Dual	
Codeverlauf (Drehrichtung)	clockwise (cw) oder counterclockwise (ccw)	
Mechanische Parameter		
Gehäusewerkstoff	Leichtmetall	
Masse	0,25	kg
Gehäusedurchmesser	50,8	mm
Wellenwerkstoff	nichtrostender Stahl	
Wellendurchmesser	6	mm
Betriebsdrehzahl max.	3 000	min^{-1}
Anlaufdrehmoment typ.	0,02	Nm
Betriebsdrehmoment bei 500 min^{-1}, typ.	0,02	Nm
Trägheitsmoment (Rotor)	$2{,}5 \times 10^{-6}$	kg m^2
Wellenbelastung axial, max.	25	N
Wellenbelastung radial, max.	40	N
Lagerlebensdauer (max. Betriebsdrehzahl und Belastung)	4×10^{10}	U
Arbeitstemperatur	0 bis +50	°C
Lagertemperatur	-20 bis +50	°C
Schutzart nach EN 60529	IP 65	
Widerstandsfähigkeit gegen Vibrationen		
Schwingen DIN / IEC 68-2-6 (3 Achsen)	10 - 55 Hz, Amplitude 1 mm, 6 Zyklen je 5 min	
Schock DIN / IEC 68-2-27 (3 Achsen)	6 Schocks Halbsinus, 18 ms, 30 g	
Elektrische Parameter		
Ausgangsschaltung	Gegentakt	
Betriebspannungsbereich U_B	15 bis 30	V DC
Betriebsstrom (ohne Last)	< 50	mA
Ausgangsspannung U_A bei max. Ausgangsstrom		
U_A (HIGH; 1), min.	U_B - 3	V
U_A (LOW; 0), max.	3	V
Ausgangsstrom je Ausgang max.	30	mA
Überlast- / Kurzschlußschutz	nichtrastender thermischer Überlastschutz	
EMV-Schutzanforderungen gemäß CE	erfüllt	
Ausgabefrequenz max.	300 000	Hz
Anschlußart		
PUR-Leitung geschirmt, Länge 2 m	●	
Steckverbinder 12pol. Stift	●	

Anschlußbelegung

Bezeichnung	**Adernfarbe**	**Stecker-Pin**	**Bezeichnung**	**Adernfarbe**	**Stecker-Pin**
Ausgang 1	BK	1	Ausgang 7	GY	7
Ausgang 2	WH	2	Ausgang 8	RD	8
Ausgang 3	YE	3	-	nicht belegt	9
Ausgang 4	GN	4	Schirm	transparent	Gehäuse
Ausgang 5	VT	5	0 Volt	BU	11
Ausgang 6	PK	6	$+U_B$	BN	12

Technische Änderungen vorbehalten 08/97

Low-cost Encoder with Diameter of 50 mm

E6CP-A

CSM_E6CP-A_DS_E_5_1

General-purpose Absolute Encoder with External Diameter of 50 mm

- Absolute model.
- External diameter of 50 mm.
- Resolution: 256 (8-bit).
- Lightweight construction using plastic body.

Be sure to read *Safety Precautions* on page 5.

Ordering Information

Encoders [Refer to *Dimensions* on page 5.]

Power supply voltage	Output configuration	Resolution (divisions)	Connector for H8PS Cam Positioner	Model
5 to 12 VDC	Open-collector output	256 (8-bit)	None	**E6CP-AG3C 256P/R 2M**
12 to 24 VDC				**E6CP-AG5C 256P/R 2M**
			Supported	**E6CP-AG5C-C 256P/R 2M**

Note: When connecting to the H8PS, use the E6CP-AG5C-C, which is connected using a connector. It cannot be used on other models.

Accessories (Order Separately)

[Dimensions: Refer to *Accessories* for coupling dimensions and to page 5 for the dimensions of other accessories.]

Name	Model	Remarks	
Couplings	**E69-C06B**	Provided with the E6CP-AG3C and E6CP-AG5C.	
	E69-C68B	Different end diameter	
	E69-C610B	Different end diameter	
	E69-C06M	Metal construction	
Servo Mounting Bracket	**E69-2**	Provided with the product. (Three brackets in a set.)	
Extension Cable	**E69-DF5**	5 m	Models are also available with 15-m and 98-m cables.
	E69-DF10	10 m	
	E69-DF20	20 m	

Refer to *Accessories* for details.

Ratings and Specifications

Item / Model		E6CP-AG3C	E6CP-AG5C	E6CP-AG5C-C
Power supply voltage		5 VDC –5% to 12 VDC +10%, ripple (p-p): 5% max.	12 VDC –10% to 24 VDC +15%, ripple (p-p): 5% max.	
Current consumption*1		90 mA max.	70 mA max.	
Resolution (rotations)		256 (8-bit)		
Output code		Gray code		
Output configuration		Open-collector output		
Output capacity		Applied voltage: 28 VDC max. Sink current: 16 mA max. Residual voltage: 0.4 V max. (at sink current of 16 mA)		
Maximum response frequency*2		5 kHz		
Logic		Negative logic (high = 0, low = 1)		
Accuracy		±1° max.		
Direction of rotation		Output code incremented by CW (as viewed from the end of the shaft)		
Rise and fall times of output		1 μs max. (Control output voltage: 16 V, Load resistance: 1 kΩ, Output cable: 2 m max.)		
Starting torque		0.98 mN·m max.		
Moment of inertia		1×10^{-6} kg·m² max.		
Shaft loading	Radial	30 N		
	Thrust	20 N		
Maximum permissible speed		1,000 r/min		
Ambient temperature range		Operating: –10 to 55°C (with no icing), Storage: –25 to 85°C (with no icing)		
Ambient humidity range		Operating/Storage: 35% to 85% (with no condensation)		
Insulation resistance		20 MΩ min. (at 500 VDC) between current-carrying parts and case		
Dielectric strength		500 VAC, 50/60 Hz for 1 min between current-carrying parts and case		
Vibration resistance		Destruction: 10 to 55 Hz, 1.5-mm double amplitude for 2 hours each in X, Y, and Z directions		
Shock resistance		Destruction: 1,000 m/s² 3 times each in X, Y, and Z directions		
Degree of protection*3		IEC 60529 IP50		
Connection method		Pre-wired Models (Standard cable length: 2 m)		Connector Models (Standard cable length: 2 m)
Material		Case: ABS, Main unit: PPS, Shaft: SUS416, Mounting Bracket: Galvanized iron		
Weight (packed state)		Approx. 200 g		
Accessories		Coupling (excluding Connector Models), Servo Mounting Bracket, Instruction manual		

*1. An inrush current of approximately 8 A will flow for approximately 0.3 ms when the power is turned ON.
*2. The maximum electrical response speed is determined by the resolution and maximum response frequency as follows:

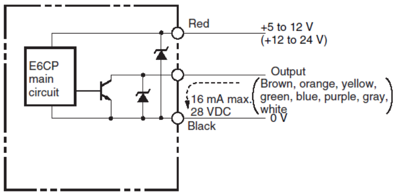
$$\text{Maximum electrical response speed (rpm)} = \frac{\text{Maximum response frequency}}{\text{Resolution}} \times 60$$

This means that the Rotary Encoder will not operate electrically if its speed exceeds the maximum electrical response speed.
*3. No protection is provided against water or oil.

I/O Circuit Diagrams

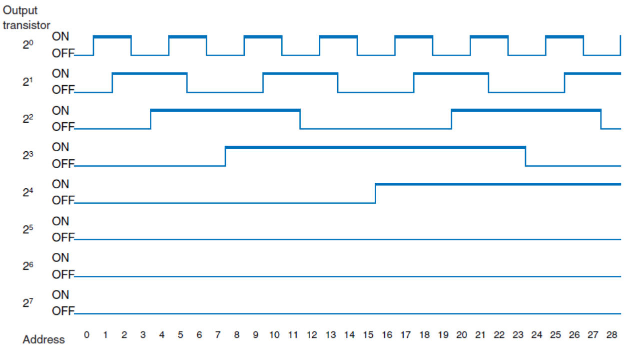
E6CP-AG3C, E6CP-AG5C	E6CP-AG5C-C

Output Circuits



Output mode

Direction of rotation: CW (as viewed from end of shaft)



Connection

Color	E6CP-AG3C	E6CP-AG5C
Red	Power supply 5 to 12 VDC	Power supply 12 to 24 VDC
Black	0 V (common)	
Brown	Output 2^0	
Orange	Output 2^1	
Yellow	Output 2^2	
Green	Output 2^3	
Blue	Output 2^4	
Purple	Output 2^5	
Gray	Output 2^6	
White	Output 2^7	

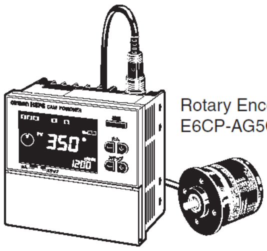
Note: The circuit is the same for all bit outputs.
Each E6CP Rotary Encoder has one main circuit.

Terminal No.	E6CP-AG5C-C
1	Connected internally
2	
3	Output 2^5
4	Output 2^1
5	Output 2^0
6	Output 2^7
7	Output 2^4
8	Output 2^2
9	Output 2^3
10	Output 2^6
11	---
12	Power supply: 12 to 24 VDC
13	0 V (common)

Note: The circuit is the same for all bit outputs.
Each E6CP Rotary Encoder has one main circuit.

Positioner Connection Example

H8PS Cam Positioner Connection



Note: The E6CP-AG5C cannot be connected to the H8PS.

Ordering Information

Model
H8PS-8A
H8PS-8AP
H8PS-8AF
H8PS-8AFP
H8PS-16A
H8PS-16AP
H8PS-16AF
H8PS-16AFP
H8PS-32A
H8PS-32AP
H8PS-32AF
H8PS-32AFP

Specifications

Rated voltage	24 VDC
Cam precision	0.5° (for 720 resolution), 1° (for 256/360 resolution)
No. of output points	8-point output type: 8 cam outputs, 1 RUN output, 1 pulse output 16-point output type: 16 cam outputs, 1 RUN output, 1 pulse output 32-point output type: 32 cam outputs, 1 RUN output, 1 pulse output
Encoder response	RUN mode, test mode: 256/360 resolution .... 1,600 r/min max. (1,200 r/min when advance compensation is set for four cams or more) 720 resolution .... 800 r/min max. (600 r/min when advance compensation is set for four cams or more)
Additional functions	• Origin compensation (zeroing) • Rotation direction switching • Angle display switching • Teaching • Pulse output • Angle/number of rotations display switching • Puncture * • Angle advance • Number of rotations alarm output • Setting with support software (order separately) *

Note: For 16-point and 32-point output types only

Programmable Controller Connection

Connection is possible with the CQM1H-CPU51 and CQM1H-ABB21.

Refer to the *CQM1H Programmable Controller Catalog* (P050) for details on the CQM1H Programmable Controller.

Safety Precautions

Refer to *Warranty and Limitations of Liability*.

⚠ WARNING

This product is not designed or rated for ensuring safety of persons either directly or indirectly.
Do not use it for such purposes.

Precautions for Correct Use

Do not use the Encoder under ambient conditions that exceed the ratings.

● Mounting

For front-surface mounting, the maximum tightening torque is 1.76 N·m. (Effective screw length: 7 mm min.)

● Wiring

Spurious pulses may be generated for outputs when power is turned ON. Wait at least 1 s after turning ON the power to the Encoder before using the connected device.

● Connection

Spurious pulses may be generated when power is turned ON and OFF. Wait at least 1 s after turning ON the power to the Encoder before using the connected device, and stop using the connected device at least 1 s before turning OFF the power to the Encoder. Also, turn ON the power to the load only after turning ON the power to the Encoder.

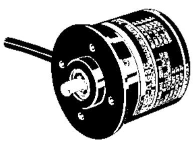
(Unit: mm)

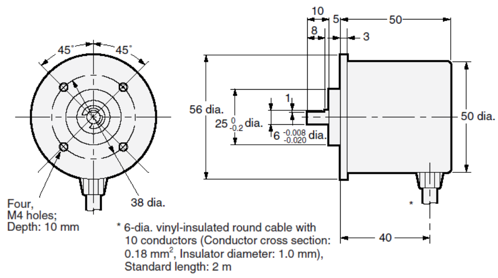
Dimensions

Tolerance class IT16 applies to dimensions in this datasheet unless otherwise specified.

Encoder

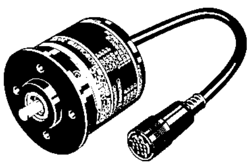
E6CP-AG3C
E6CP-AG5C

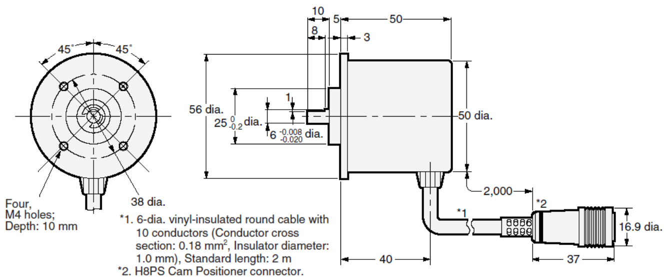




The E69-C06B Coupling is provided.

E6CP-AG5C-C



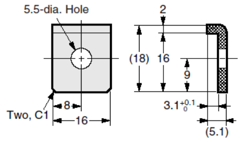


The E69-C06B Coupling is sold separately.

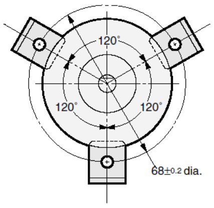
Accessories (Order Separately)

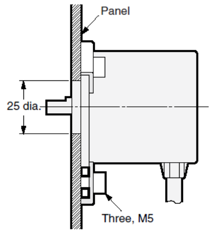
Servo Mounting Bracket

E69-2



Mounting Bracket Installation

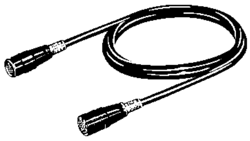


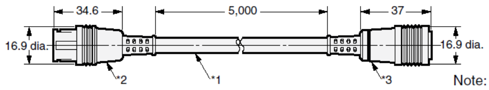


Note: Provided with the product.

Extension Cable

E69-DF5





*1. 6-dia. shielded cable with 12 conductors
(Conductor cross section: 0.2 mm^2, Insulator diameter: 1.1 mm),
Standard length: 5 m
*2. Connects to connector on E6CP-AG5C-C.
*3. Connects to H8PS Cam Positioner.

Note: 1. The E69-DF5 (5 m) is also available with the following cable lengths: 10 m, 15 m, 20 m, and 98 m.
2. Cable can be extended to 100 m when the H8PS Cam Positioner is connected.

Couplings

E69-C06B
E69-C68B
E69-C610B
E69-C06M

Refer to *Accessories* for details.

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CSM_E6CP-A_DS_E_5_1 10/10 Note: Specifications are subject to change.

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