Barcode Quality Evaluation Guide

12 November 2021

Anker Andersen realizes that many of our customers often experience problems with too many no-reads in their production lines. Customers ascertain that bottles are sorted out as no-reads even if the bottles apparently look nice and healthy and the barcode adhered to it seems to be fine and undamaged. They tend to blame the machine or even themselves in not maintaining the machine properly. But after cleaning the problem often persists and the customer is confused and unable to diagnose the problem. Finally the customer calls Anker Andersen and claims that the machine produces a lot of no-reads and the problem seems to be related to a certain bottle with a specific barcode.

This document will try to help our customers finding the answers themselves. Because when the problem is related to a specific article number with a specific barcode, the problem is most often related to the barcode itself and shall not be found in the machine set-up or in lack of proper maintenance of the machine.
The document will explain the most common characteristics of barcodes and guide you through the troubleshooting of non- or difficult readable barcodes. The only thing you need apart from this document is a magnifying glass.

We realize that this document will become quite detailed on the technical characteristics related to barcodes, but we will do our utmost to explain the effects of defect barcodes in an easy and understandable way – so we urge you to hang on and enjoy the ride.

For your information there does exist an international standard, which has to be implemented in barcode design. Barcode designers and printers have to comply with the requirements of this standard. For those of you who are nerdy enough, the document can be found by using the following link:

https://www.gs1.org/docs/barcodes/GS1_General_Specifications.pdf

General overview

There are essentially two types of barcodes, 1-dimensional and 2-dimensional.

The 1-dimensional barcodes consist of a variable number of dark bars on a bright background. The most commonly used 1-dimensional barcodes in the retail industry are the EAN-8 and EAN-13 barcodes and UPC-A and UPC-E in the US and Canada. The EAN-8 barcode consists of 22 bars and the EAN 13 consists of 30 bars. This paper will not go into any further details concerning the algorithms involved in creating barcodes as this is quite a complex matter.

The barcode quality evaluation guide will focus on the EAN barcode types as most of the problems are common and not related to a specific barcode type.

The 2-dimensional barcodes are comprised of a number of dark squares organized in an apparently chaotic chessboard like pattern and with some special corner markings to identify the reading orientation. The use of 2-dimensional barcodes in the retail industry is up until now not very widespread as most barcode readers at point of sales terminals are not able to read these barcodes. This paper will accordingly not deal with 2-dimensional barcodes.

Although the conclusions in this document are given as “recommendations” to the barcode printer you will, if a close study of a barcode concludes that those recommendations are not met, have potential problems with reading these barcodes in your counting machines and you may have identified the real cause of the problem with no-reads related to specific barcodes.

1-dimensional barcode troubleshooting

Barcode size

Below in fig. 1 examples of EAN-8 and EAN-13 barcodes are shown.

Fig. 1, EAN-8 and EAN-13 barcodes.

The first and very important characteristic of barcodes is the size. In barcode terminology, we speak about “magnification factor”. In the retail point of sales context a magnification factor between 0,8 and 2,0 is allowed. However, every application sets its own limitations on the choice of size. Some items are simply not large enough to house a 2,0 barcode and some items have odd shapes which limit the choice of size. Below in table 1 is given the dimensions of EAN-13 and UPC-A barcodes as a function of the magnification factor.

Magnification factor	X-dimension [mm]	EAN-13/UPC-A dimensions [mm]:		Quiet zones [mm]	
		Width*	Height**	Left	Right
0.80	0.264	29.83	18.28	2.90	1.85
0.85	0.281	31.70	19.42	3.09	1.96
0.90	0.297	33.56	20.57	3.27	2.08
0.95	0.314	35.43	21.71	3.45	2.19
1.00	0.330	37.29	22.85	3.63	2.31
1.05	0.347	39.15	23.99	3.81	2.43
1.10	0.363	41.02	25.14	3.99	2.54
1.15	0.380	42.88	26.28	4.17	2.66
1.20	0.396	44.75	27.42	4.36	2.77
1.25	0.413	46.61	28.56	4.54	2.89
1.30	0.429	48.48	29.71	4.72	3.00
1.35	0.446	50.34	30.8	4.90	3.12
1.40	0.462	52.21	31.99	5.08	3.23
1.45	0.479	54.07	33.13	5.26	3.35
1.50	0.495	55.94	34.28	5.45	3.47
1.55	0.512	57.80	35.42	5.63	3.58
1.60	0.528	59.66	36.56	5.81	3.70
1.65	0.545	61.53	37.70	5.99	3.81
1.70	0.561	63.39	38.85	6.17	3.93
1.75	0.578	65.26	39.99	6.35	4.04
1.80	0.594	67.12	41.13	6.53	4.16
1.85	0.611	68.99	42.27	6.72	4.27
1.90	0.627	70.85	43.42	6.90	4.39
1.95	0.644	72.72	44.56	7.08	4.50
2.00	0.660	74.58	45.70	7.26	4.62

Table 1, Barcode dimensions and quiet zone specifications.

Anker Andersen A/S
Anker Andersens Vej 1
DK-7160 Tørring
Cvr DK 26 66 13 31
Tel. +45 7033 2233
info@anker-andersen.com
www.anker-andersen.com

This table will be discussed together with the information given in fig. 2.

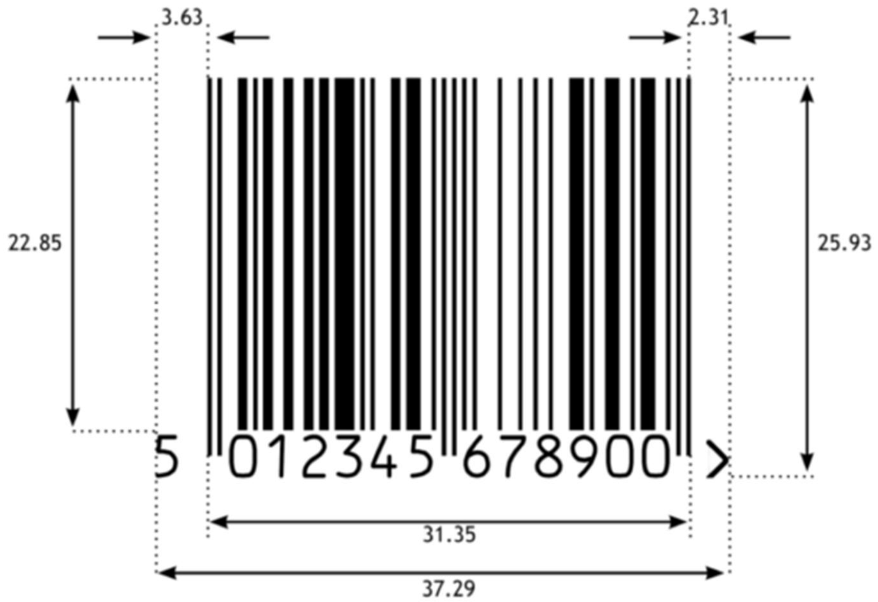

Fig. 2, EAN-13 barcode, magnification factor 1,00.

Table 1 shows us that with a magnification factor of 1,0, the EAN-13 has the following dimensions, the corresponding numbers shown for EAN-8 barcode:

	EAN-13	EAN-8
Magnification factor:	1,00	1,00
Barcode width:	37,29 mm	26,73 mm
Barcode height:	25,93 mm	21,31 mm
Quiet zone left:	3,63 mm	2,31 mm
Quiet zone right:	2,31 mm	2,31 mm

Concerning barcode size one might think “the bigger the better” but that is certainly not the truth. In large logistic applications, big crates/pallets and big parcels it’s normally true as most of the barcodes are adhered to flat and plane surfaces and the reading of the barcodes is performed by fixed installed automatic readers.

However, in the retail industry we have to deal with millions of items with as many different sizes and different shapes. Therefore it is of mandatory importance that the barcodes are designed and sized accordingly.

Our yearlong experience tells us that the sizes of barcodes on beverage containers should in general be within the following ranges:

Anker Andersen A/S
Anker Andersens Vej 1
DK-7160 Tørring
Cvr DK 26 66 13 31

Tel. +45 7033 2233
info@anker-andersen.com
www.anker-andersen.com

Recommendation 1:

	Min	Max
EAN-8 barcode	20 mm	30 mm
EAN-13 barcode	30 mm	40 mm

Please note that the stated sizes include the quiet zones (discussed later).

Barcode orientation

Contrarily to ordinary squared parcels where the orientation does not really matter, as the barcode is adhered to a flat surface, the orientation is often critical in the retail industry as we here deal with items that are mainly presented in one direction – standing up or lying down. This especially counts for beverage containers. Therefore we pay interest to the orientation of the barcode. In fig. 3 is shown the two types, picket fence and step ladder. The names speak for themselves.

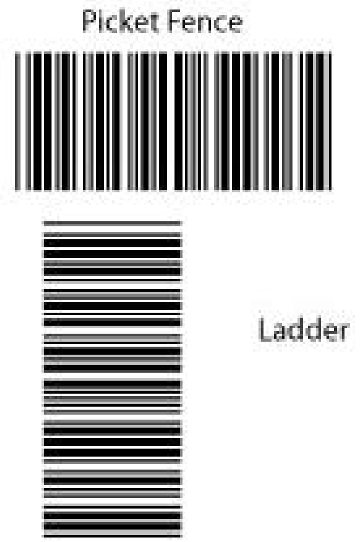

Fig. 3, barcode orientation, picket fence and step ladder.

We will pay some attention to the two types. Beverage containers are approximately cylindrical which means that a picket fence barcode will wrap around the container and consequently be distorted from a camera point of view. Try to look at a picket fence barcode on a round bottle and observe how the bars of the barcode become thinner the more you turn it. This means that the dimensions of bars and spaces change and the barcode becomes unreadable.

In fig. 4 we show a horrible example of such a barcode. This barcode is not readable and will inevitably be sorted out as a no-read in the no-read tray.

There are no exact measures for what is acceptable and what is not as it has to be assessed in every single case. Our experience tells us that picket fence barcodes should be avoided in general on beverage containers.

Consequently use of picket fence barcodes has been abandoned on all non-refillable beverage containers in the German deposit system to improve system performance.

Anker Andersen A/S
Anker Andersens Vej 1
DK-7160 Tørring
Cvr DK 26 66 13 31

Tel. +45 7033 2233
info@anker-andersen.com
www.anker-andersen.com

Fig. 4, Picket fence barcode wrapped around a PET bottle.

Recommendation 2:

Do not use picket fence barcodes on beverage containers in the deposit system as they in general create problems. If you do anyway, be extremely careful with the choice of barcode size.

Barcode quiet zone

The third important issue with barcodes is the “quiet zone” parameter. There are two quiet zones in a barcode, the left and the right (or top and bottom on step ladder barcodes). What are they used for?
The quiet zones are essential to the barcode readers as they serve the purpose of separating the barcode itself from everything else on a label. When the barcode reader scans the label for a valid barcode it searches all over the label for valid barcode candidates. On most labels there is plain text and this can unfortunately be interpreted as a barcode candidate as text is also a mixture of bars and spaces. To efficiently separate text from barcodes it is essential to obey the guidelines and recommendations for sizes of quiet zones.

In fig. 5 is shown 2 examples of barcodes with no or insufficient quiet zones.

Fig. 5, Quiet zones.

Anker Andersen A/S
Anker Andersens Vej 1
DK-7160 Tørring
Cvr DK 26 66 13 31
Tel. +45 7033 2233
info@anker-andersen.com
www.anker-andersen.com

Recommendation 3:

Quiet zones must be at least as specified in table 1 and preferably larger. We recommend at least 5 mm both left and right independent of barcode size.

Barcode width/height relationship

Another parameter is the width/height relationship. As can be seen from table 1 the longer the barcode is, the higher it should be. We often see barcodes with reduced height to save space on the label for other purposes, but doing so is a bad idea. In fig. 6 are shown 2 examples where the width/height relationship is not met.

Fig. 6, Width/height relationship

Recommendation 4:

Make sure that the width/height relation complies with table 1.

Other important barcode deficiencies

And now it’s becoming a little bit difficult. In the following we will discuss parameters like “Symbol contrast”, “Edge contrast”, Barcode colors and label reflectance. Please don’t give up – stay tuned!
You have to understand that the vast majorities of barcode readers use red light to detect barcodes. This means that when you expose barcodes to red light the amount of light being reflected from the barcode elements vary according to the following:

- Symbol contrast
- Edge contrast
- Barcode color
- Label material characteristics
- Label conditions

Symbol contrast:

The symbol contrast is basically the difference in the (light-) reflectance of the bars compared to the reflectance of the spaces. Normally the bars are black and the spaces are white. But unfortunately black is not always black and white is not always white.

As a barcode reader does not perceive colors like the human eye it’s easier to explain the contrast problem with the use of colors. Have a look at the barcode in fig. 7. It’s obvious that this is a no-go as even the human eye has difficulties distinguishing the bars from the spaces. There is only one combination which optimizes the symbol contrast and that is “black and white”.

Anker Andersen A/S
Anker Andersens Vej 1
DK-7160 Tørring
Cvr DK 26 66 13 31
Tel. +45 7033 2233
info@anker-andersen.com
www.anker-andersen.com

Fig. 7, Symbol contrast

Recommendation 5:

The difference in light reflected from the bars and the spaces in a barcode must be as high as possible and to achieve this in practice the bars need to be black on a white background.

Edge contrast:

The edge contrast is a different matter although the bars still have to be black and the spaces still have to be white. It’s about the fact that the edges separating bars and spaces have to be straight and sharp, not curved or blurred. Fig. 8 illustrates a barcode which has a very bad edge contrast and the edges are not even straight.

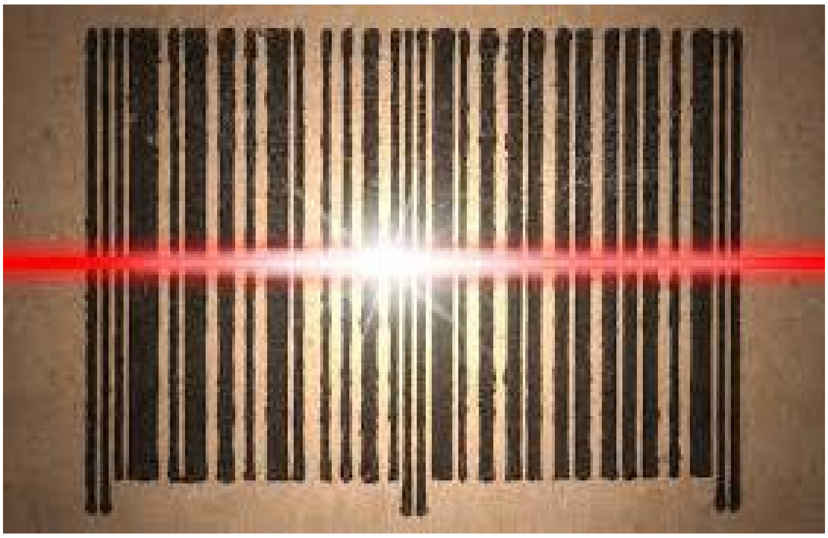

Fig. 8, Edge contrast

As previously mentioned, the barcode readers use red light to read and detect the barcode and therefore colors are not perceived in the same way by a barcode reader as the human eye. Even if some combinations of colors are acceptable in barcode design, one should always stick to “black and white”.
Another important parameter, which does not really concern the barcode itself, is the material on which the barcode is printed – the label. One often has the impression that there is an ongoing fight between the smart marketing guys and the people responsible for the operation of the logistic process. The marketing guys wish to present the items in a smart and sexy way to attract the customers whereas the technical guys want to make the system as safe and robust as possible.

Anker Andersen A/S
Anker Andersens Vej 1
DK-7160 Tørring
Cvr DK 26 66 13 31

Tel. +45 7033 2233
info@anker-andersen.com
www.anker-andersen.com

Recommendation 6:

The transitions between bars and spaces in a barcode must always be sharp and straight.

Barcode color:

In fig. 9 is shown some different combinations of colors for the bars and spaces. Some of them are artistically beautiful but absolutely no-go for use in the industry.

Fig. 9, Different combinations of colors for bars and spaces.

If you study the color combinations shown in fig. 9, you will even intuitively and quickly realize that the best combination is the upper left – black and white.

Anker Andersen A/S
Anker Andersens Vej 1
DK-7160 Tørring
Cvr DK 26 66 13 31
Tel. +45 7033 2233
info@anker-andersen.com
www.anker-andersen.com

Recommendation 7:

Barcodes should always be printed with black bars on a white background.

Label material and condition:

Labels are coming in a number of different materials such as paper, plastic, transparent plastic and even metal (cans). All of these have different optical characteristics meaning that the readability of barcodes printed on those different materials sometimes is being challenged.

On top of that many manufacturers of beverage containers wish to differentiate their products from those of their competitors by giving the containers funny shapes and even making the surface wrinkled.
It's outside the scope of this document to give detailed recommendations for all kinds of combinations of bottle material, label material, bottle geometry etc. but instead we will show you some examples of bad designs in the following. If you follow the instructions in this document you will over time gather enough experience to create your own "mind based" database of how barcodes should be designed and presented not to cause problems in the counting machines.

Fig. 10, Bad colors and deformed barcode due to bottle curvature.

This barcode is printed on a transparent plastic label with changing geometry and in wrong color combinations. Changing geometry leads to distortion of barcode geometry.

Fig. 11, Bottle substrate and color used as bars in the barcode.

This barcode is also printed on a transparent plastic label. Remember that the barcode should always be printed with black bars on a white background.

Anker Andersen A/S
Anker Andersens Vej 1
DK-7160 Tørring
Cvr DK 26 66 13 31
Tel. +45 7033 2233
info@anker-andersen.com
www.anker-andersen.com

Fig. 12, Barcode printed with white bars on the raw metal surface giving a bad contrast.

Print growth and print dilution:

Now it's becoming a little bit technical but print growth or the opposite print dilution is often a problem if the label printer is not careful enough when transferring the label layout from the label designer to the printer software. The printer has to take into account a lot of parameters including especially the label material. Is it paper, plastic, shrink foil or even metal (in the case of aluminum cans)? Each type of label material requires specific settings for the printing machine to be used. If this process is not managed properly it can lead to print growth or print dilution/overexposure. Fig. 13 shows both cases.

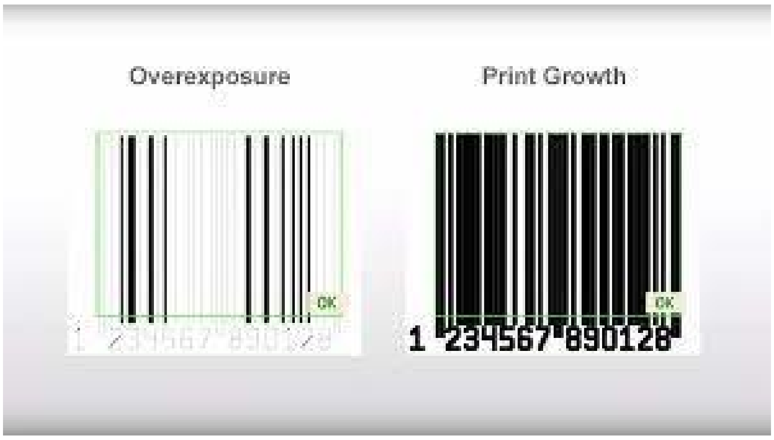

Fig. 13, Print dilution and print growth – extreme examples.

As we have learned, a perfect barcode is made up of black bars on a white background. The barcode information is coded into the variable width of the bars versus the spaces. The minimum width of a bar defines the barcode module size. In the perfect world the width of the thinnest bar equals the width of the thinnest space.

If this is not the case we can have one of either cases:

1: The width of the thinnest bar is less than the width of the thinnest space. This is print dilution also named overexposure. The whole (or part of) barcode seems very bright and your magnifier will easily show you the difference in width of the minimum bar and space.

2: The width of the thinnest space is less than the width of the thinnest bar. This is print growth, the term coming from the optical illusion that the bars seem to "grow" in each direction and the entire barcode seems overall very dark. Again your magnifier will reveal the problem clearly.

Anker Andersen A/S
Anker Andersens Vej 1
DK-7160 Tørring
Cvr DK 26 66 13 31
Tel. +45 7033 2233
info@anker-andersen.com
www.anker-andersen.com

Recommendation 8:

The printer must be extremely careful with the settings of the printing machine to obtain a perfect proportional relation between the width of the bars and spaces in a perfect barcode.

Finally we have added a small section, which is not really related to the barcode itself but merely to some issues influencing the beverage containers during their lifetime such as beverage container design and handling/mishandling by the consumer. The issues however greatly affect the readability of the barcodes which at the end of the lifetime of the beverage container is the one and only means for paying back the deposit fee to the customer, identifying the type of beverage container and finally recycling it properly.

Wrinkled labels:

The commendable initiatives to reduce the use of especially plastic in the production of beverage containers has unfortunately had a severe side effect. Minimizing the amount of material weakens the beverage container and reduces stability especially when the container is partly empty. Consequently, the beverage container manufacturer has been forced to find other means to reinforce the container.

One of these means has been to make the surface of the beverage container wrinkled as shown in fig. 14.

Fig. 14, Two wrinkled labels examples.

As you can see, the surface of the label is no more smooth. The wrinkled surface can and will lead to deformation of the label distorting the geometric properties of the barcode. This means that the relationship of the width of bars and spaces becomes affected.

The effect, as clearly seen in fig. 14 is reminiscent of the effects of print growth and print dilution. With print growth and print dilution the effect applies for the entire barcode whereas with wrinkled labels, the problem appears locally in different areas of the barcode.

Recommendation 9:

The artist creating the beverage container and decorating it should be aware that the area beneath the barcode and supporting the barcode should be smooth and not wrinkled.

Deformed containers and labels:

The last issue that we wish to point your attention to is the sad fact that even the consumers are not perfect. One might think that the consumer, having paid the deposit fee of the beverage container in the supermarket he/she would make his/her utmost to ensure that he/she would have the best possible chances to redeem the money when delivering back the beverage container for recycling. Unfortunately many especially young men seem to consider crunching cans with their hands as a way of showing their manhood. And we unfortunately get the results as shown in fig. 15.

Anker Andersen A/S
Anker Andersens Vej 1
DK-7160 Tørring
Cvr DK 26 66 13 31

Tel. +45 7033 2233
info@anker-andersen.com
www.anker-andersen.com

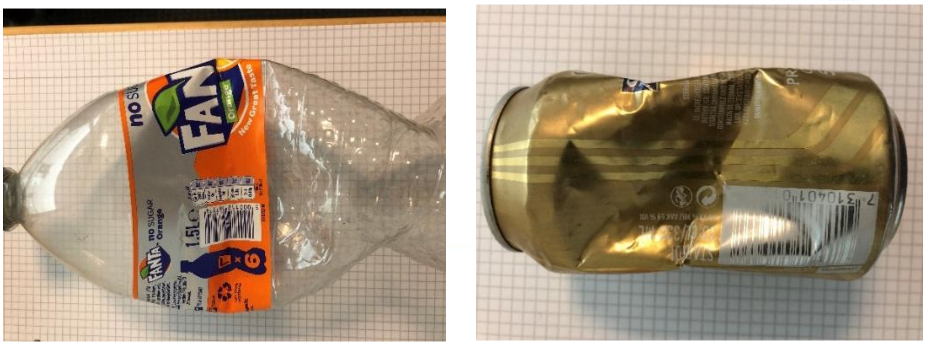

Fig. 15, Deformed beverage containers.

Recommendation 10:

Dear customer/consumer. When you have finished your drink – please treat the empty container with respect. It's an asset. You will get your deposit fee back, the container will be recycled, we use less virgin materials in the manufacturing process and last but not least, the world will be a better place to live.

Postscript:

After having studied this document we hope you have got some understanding of good praxis within printing and presentation of good and readable barcodes. You will probably also understand that assessing the quality of a barcode is not a "black and white" exercise (sorry for the term). Even close study of a barcode will in many cases not tell you one cause for bad readability as bad readability is often related to combinations of deficiencies.

This fact is also reflected in the way the industry has standardized barcode deficiencies into a barcode quality assessment procedure called "Barcode grading". Barcode grading is a way to determine whether a barcode will scan easily or not. A barcode grader also known as a barcode verifier will test or look for 9 different parameters of the barcode and calculate an overall grading of the barcode. Those are the following:

1. Edge determination
2. Minimum reflectance
3. Symbol contrast
4. Minimum edge contrast
5. Modulation
6. Defects
7. Decode
8. Decodability
9. Quiet zone

Some of the parameters in this grading procedure have not been covered by this document because they are not easily detectable by the human eye even with magnifying glasses. So they are not relevant for a quick assessment of barcode quality.

A barcode verifier will grade barcodes in 5 categories ranging from A to F, where A is good and F is very bad. We don't necessarily recommend use of a barcode verifier in your workshop because following the recommendations given in this document you will be able to solve more than 90% of problems with difficult readability of 1-dimensional barcodes.

We hope you have enjoyed the ride and hope we have piqued your interest for barcode design, printing and quality assessment.

Anker Andersen A/S
Anker Andersens Vej 1
DK-7160 Tørring
Cvr DK 26 66 13 31
Tel. +45 7033 2233
info@anker-andersen.com
www.anker-andersen.com