

A summary of data and information on Norton Commando main bearings

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Abstract:

This document reviews and presents a range of old and new data and information about Norton Commando motorcycle main bearings and investigates the bearings used in production and their modern replacements. This model of motorcycle, which was produced between 1967 and 1978, had a particular problem with excessive main bearing failures in 1972 and 1973 after the development and sale of a more highly tuned variant which used the 'Combat' engine. Norton resolved the problem using two different types of roller bearing one of which Norton named 'superblend'. A bearing with the same designation as one of these types is still specified and used to this day. This is the FAG NJ306E cylindrical roller bearing supplied under Norton part number 064118.

A range of information sources are used including; the Norton Owners Club website, the Access Norton Forum, contemporary magazine articles, known Norton factory service release sheets, reference books, bearing manufacturer catalogues and contemporary Norton brochures. Sources of information are referenced. For comparison purposes, a modern roller bearing of the equivalent designation NJ306E has also been examined and compared with others available including a new old stock RHP 6/MRJA30 'superblend'. In addition INA FAG has provided clarification on the use of the term 'Superblend' and also supplied a diagram of the roller profile of the modern bearing.

It is concluded that only one of the two types of bearing that resolved the problems had modified rollers, at the time of introduction, which differed from the norm in narrowing towards the edges. This 'partial crowning' was novel at the time but results in the relatively minor narrowing the roller diameter by a maximum of approximately 2.8 thousandths of an inch (equivalent to <0.7% of the maximum roller diameter) over approximately one third of the bearing length. This is the 6/MRJA30 bearing designated 'Superblend' by Norton in a service release and marked as manufactured by either R&M (Ransome & Marles) or RHP (Ransome, Hoffman & Pollard). It is occasionally described as having 'barrel shaped or barrelled' rollers. This bearing is obsolete and has probably not been made since the early 1970s. The other type of bearing, the FAG NJ306E has evolved over time in terms of roller edge profile and increased loading capacity. The evidence indicates that the FAG NJ306E of 1973 was a standard cylindrical roller bearing albeit with a higher loading capacity than many other bearings in use at the time. The latest bearing from FAG (and bearings from other manufacturers) have a 'logarithmic' roller edge profile. This narrows the roller edge diameter of the FAG bearing by a maximum of approximately 1.4 thousandths of an inch (equivalent to 0.3% of the maximum roller diameter). There is no evidence that any roller bearings for this application ever had barrel-shaped rollers, i.e. having a curved edge with a constant radius over their full length. Describing the rollers used in any of these bearings as barrel-shaped is at best an exaggeration. Barrel roller bearings do exist, e.g. manufactured by FAG, but data on these bearings show that they are unsuitable for this application.

The term 'Superblend' has no engineering definition and its use has become increasingly ambiguous in its application to bearings with varying specifications. Discussions about main bearings would be better based on bearing specifications, at the time of manufacture, and manufacturer's designations and data. In the author's opinion the term 'Superblend' introduces ambiguity and is potentially confusing.

This paper also concludes that bearings from manufacturers other than FAG are likely to be suitable and that there is no evidence that bearings with roller cages made of glass-fibre reinforced polyamide – designated TVP2 by FAG – would be unsuitable for this application. The roller cage material favoured by owners and suppliers is usually machined brass – designated M1 by FAG. The full designation for the FAG bearing usually supplied is NJ306-E-M1-C3.

A synopsis of the findings is set out in 'Roadholder' articles in Issue 352 (April 2017) and Issue 366 (June 2018).

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A summary of data and information on Norton Commando main bearings

Purpose

The purpose of this document is to draw together old and new data and information and investigate the types of main bearings for Norton Commando motorcycles manufactured between 1967 and 1978. The original roller main bearing designated 'Superblend' by Norton is compared with its current replacement which is a widely available modern bearing, compatible with the same use, which is also often marketed as 'Superblend'. Although none of this paper will be new information to the '*cognoscenti*' there are many who are taking at face value information that is open to misinterpretation. This is also potentially artificially limiting the selection of bearings for this application.

This search for information has been initiated following the acknowledged work of Jim Comstock of the Norton Motorcycle Machine Shop in Pueblo County, Colorado. Jim had the idea of accurately measuring a roller taken from a main bearing of the FAG NJ306E type removed from a 1974 850 Commando with under 7000 miles on the clock. Jim found that the roller was level over most of its length with just a small chamfer at the edges [REF1]. In other words it was 'nothing special' and much like any ordinary cylindrical bearing roller.

Notes are already available on this subject on the Norton Owners Club (NOC) website (see REF2, REF3 and REF4). Measurements by JM Leadbeater are recorded on the Access Norton Forum [REF1] and there is much relevant discussion in this thread and in [REF5].

The original 'Superblend' main bearing– Ransome & Marles (or RHP) 6/MRJA30

For the original bearings designated 'Superblend' by Norton there are details recorded by JM Leadbeater on the Access Norton forum [REF5] and [REF1]. These bearings are Ransome & Marles (or RHP) 6/MRJA30. The bearing has 13 rollers, and is an NF type (rollers attached to the inner race and a loose outer race with a lip on one side). The '6' (circled in Illustration 1) is important and is usually hand engraved on the bearing. Whilst the edge chamfer is clearly visible any partial crowning is difficult to see here. It is partial crowning that narrows the ends of the roller and is marketed as 'Superblend'. The outer bearing race is not shown.

Illustration 1: R&M 6/MRJA30 main bearing (from Access Norton Forum 'jimmytwin'):



These bearings are referred to in Service Release N2/9 (August 1972) [see Illustration 2] by manufacturer, designation and Norton Part Number 063906. This Service Release is the only known one which uses the term 'Superblend'. The rollers could be described as 'partially crowned' cylindrical rollers [REF23] to take account of the 'blending' but are definitely not barrel shaped, i.e. they are not convex with a constant radius of curvature over their entire length. The partially crowned roller profile is also known as 'aerospace' [REF11].

Illustration 2: Extract from Service Release N2/9 August 1972 (see also Page 25)

	No. N.2/9
	3
<u>NATURE OF RELEASE:</u>	Crankshaft main (roller) bearings
<u>MODELS AFFECTED:</u>	1972 Commando (all models)
<u>DISTRIBUTION:</u>	Worldwide (Distributors and Dealers)
<u>EXPLANATION:</u>	<p>In order to extend main bearing life, a change of roller main bearing specification has now been authorized, and fitted on production engines from engine number 211891.</p> <p>The new roller bearing is designated "Superblend" with an increased load carrying capacity and are supplied under part number 063906 (manufacturers part number R & M 6/MRJA30).</p>

In 2017 Anthony Curzon loaned the author an RHP 6/MRJA30 bearing from the 'new old stock' (NOS) of Geoffrey Myers Classic Motorcycles. This gave the opportunity to examine an unused bearing in detail. In 1969 R&M had joined with Hoffman's and Pollard's as subsidiaries of RHP Limited. RHP became a subsidiary of NSK Ltd of Japan in 1990. The bearing being marked as manufactured by RHP is therefore not surprising. This is a photograph of the bearing showing its manufacturer's markings.

Illustration 3: RHP 6/MRJA30 'Superblend' bearing (Bearing loaned by Anthony Curzon. Photo by author)



As with the R&M bearing the '6' is hand engraved. According to page 9 of [REF43] 'A number prefix, or "B" and a number, denote a special bearing. These often conform to standard boundary dimensions, but have some deviation from standard which is not always readily discernible.'

The following photograph shows the inner bearing race, cage and rollers of the loaned NOS RHP bearing. The crowning is visible as a distinct grey banding between the flat part of the rollers and the usual chamfered edge.

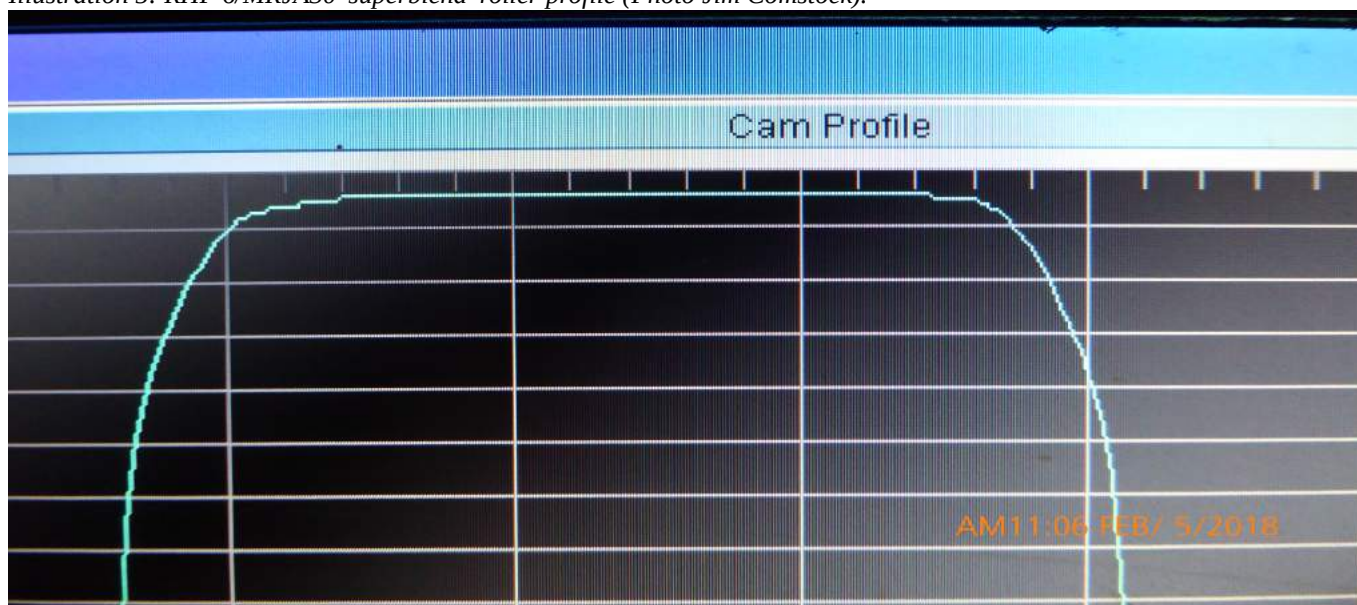
Illustration 4: RHP 6/MRJA30 'bearing showing partial crowning of the rollers (A Curzon bearing, author photo)



Additional photographs of the bearing are shown in Annex 8 on page 33 (Illustration 30).

A roller from Anthony Curzon's RHP 6/MRJA30 has also been scanned by Jim Comstock. This was the result:

Illustration 5: RHP 6/MRJA30 'superblend' roller profile (Photo Jim Comstock).



The scan confirms that the roller is parallel over the majority of its length (over 60%) and is partially crowned, i.e. tapered, at the edges. The roller profile differs from that of a standard MRJA30 roller which is parallel over most of its length (at least 80%). See comparison scans on Page 13.

The replacement – FAG NJ306E

Evidence indicates that in early 1973 Norton sought an alternative - possibly for cost or convenience reasons – and fitted standard FAG NJ306E bearings (Part Number 064118). The 'E' is important as this refers to a 'high capacity design' and appears in FAG's 1966 catalogue [REF28] although the date of introduction is unknown. This bearing has 12 rollers and is of the NJ type (see pg. 15). The earlier NJ306 had 11 rollers and was a type that was failing (as was the earlier MRJA30 without the '6' preface). Service Release N2/10 (January 1973) [see Illustration 6] refers to Norton Part No. 064118 as superseding the earlier 'Superblend' bearing 063906. The FAG NJ306E was not designated 'Superblend' by Norton in any known Service Release although the term was never withdrawn.

Illustration 6: Extract from Service Release N2/10 January 1973 (see also Page 26)

	No. N2/10
<u>CATEGORY OF RELEASE:</u>	4
<u>NATURE OF RELEASE:</u>	Extra high capacity main bearings
<u>MODELS AFFECTED:</u>	All Commando
<u>DISTRIBUTION:</u>	Worldwide (Trade only)
<u>EXPLANATION:</u>	<p>A new main bearing capable of carrying a much higher load than any offered before, has been introduced.</p> <p>The new bearing, part number 064118, supersedes the old type 063906 and will be supplied in lieu by our Parts Division. The new bearing should be fitted in pairs.</p> <p>This bearing may also be fitted to advantage to engines of 1971 and earlier models (originally fitted with a ball bearing as a timing side main bearing).</p>

The FAG NJ306E bearing is clearly different to the earlier R&M/RHP 6/MRJA30 one and is not a copy. The Norton Owners Club Commando Service Notes (Page 16) [REF6] include the following, "There are, so far, only two types of bearing I would recommend anyone to use in any Norton twin (500 up anyway). These bearings are both Superblend Roller Bearings-one from Ransome and Marles, Norton No: 063906, and one from F.A.G., Norton No: 064118. Either should be used in 500-750 engines; the factory reckon only to use the F.A.G. bearings in the 830s... Only use bearings with the following nos: NJ306E...or 6 MRJA30." Today a bearing designated FAG NJ306E is still obtainable as part number 064118 from many suppliers. See Illustration 7. An NJ306E roller bearing is listed in the 2014 FAG catalogue [REF7] on Page 422. There is no mention of any special treatment of the roller edge profile. FAG Technical publication [REF9 Page 5] indicates the edge profile is logarithmic. This profile is now also a

Illustration 7: FAG NJ306E main bearing (from Access Norton Forum, 'DogT')

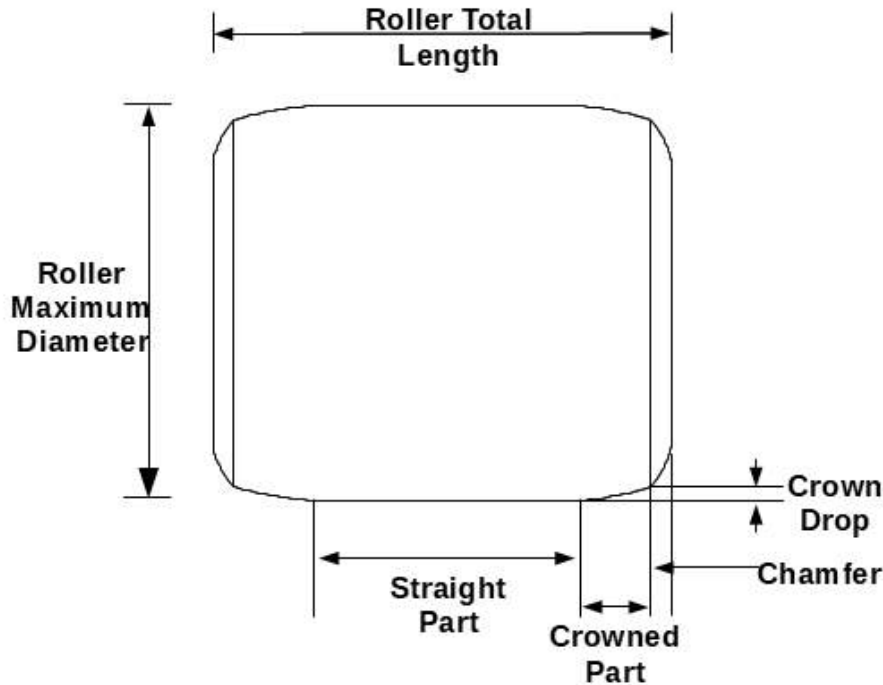


'norm' for cylindrical roller bearings from other suppliers, e.g. SKF Catalogue [REF8 Page 568]. The bearing profile has been referred to by others on the NOC website and on Access Norton. FAG's Technical Publication also indicates that the logarithmic roller '*profile prevents, under normal load conditions, life-reducing edge stresses at a tilting angle of up to 4' (4 angular minutes) between inner ring and outer ring*'. Jim Comstock's measurement [REF1] of a 1970s NJ306E indicates an edge with a chamfer but no narrowing towards the edge. The designed and manufactured edge profile has changed over time but the designation NJ306E has not changed to reflect this.

Comparison

JM Leadbeater's original measurement diagrams are shown in Annex 1 (page 21). Not all the dimensions are available but in my view there are enough to describe the 6/MRJA30 and NJ306E bearings and rollers in some detail. JM Leadbeater's measurements indicated that both types of bearing had partially crowned rollers. The following schematic for a partially crowned roller is based on that given by Fujiwara & Yamauchi [REF24].

Illustration 8: Schematic for a partially crowned roller



Characteristics of the two bearings used by Norton after August 1972 are shown in Table 1.

Table 1: Characteristics of the two bearings

Characteristic	R&M or RHP 6/MRJA30	FAG NJ306E ¹
Bearing type (see Page 15)	NF	NJ
Number of rollers	13	12
Roller shape	Cylindrical	Cylindrical
Roller Maximum Diameter	9.53mm	11mm
Crown drop	0.035mm	0.015 or 0.018mm
Straight part	6mm	8mm or 7mm
Roller Total length	9.53mm	12mm
Roller crown profile	Blended, i.e partially crowned.	Either flat with chamfer, partially crowned or logarithmic
Loading (Dynamic/Static)	35800/31000 N	51000 or 61000/48000 N
Norton Part Number	063906	064118
Status	Superseded	Current (in use)

1 Current NJ306E data is highlighted where this differs from earlier bearing version data provided by J.M. Leadbeater.

The measurements in Table 1 and loadings have been provided by JM Leadbeater [REF5] and [REF1] and shown in Annex 1. In his own words the measurements are approximate. The NJ306E cylindrical roller bearing listed in the 2014 FAG catalogue has the same roller total length, roller outer diameter and number of rollers as shown in Table 1. Based on the photographs and measurements neither bearing has a barrel-shape roller in the conventional sense, where the barrel roller profile is convex throughout its length with the corresponding requirement for a concave raceway in the outer bearing ring. (See Illustration 24 Example of a barrel-shaped roller with a fully convex edge photo in Annex 2 on page 22). Roller geometry and its effect on the relationship between bearing load and life is examined for NASA by Oswald, Zaretsky and Poplawski [REF30].

Schematically the rollers of the two 1970s bearings have the following approximate dimensions (in mm):

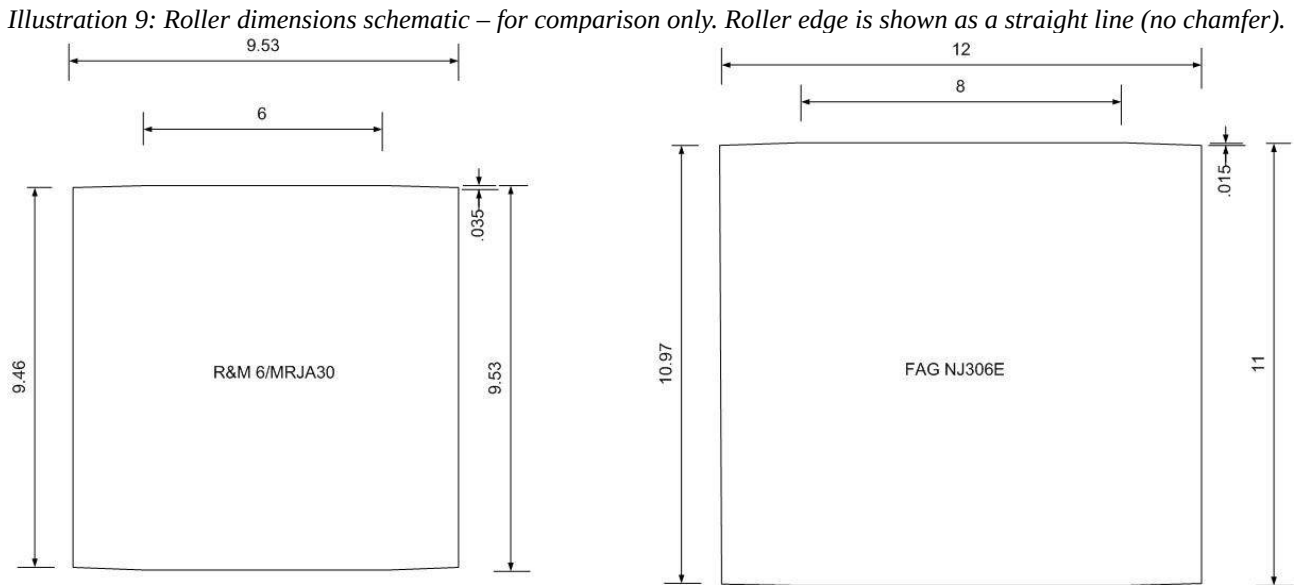
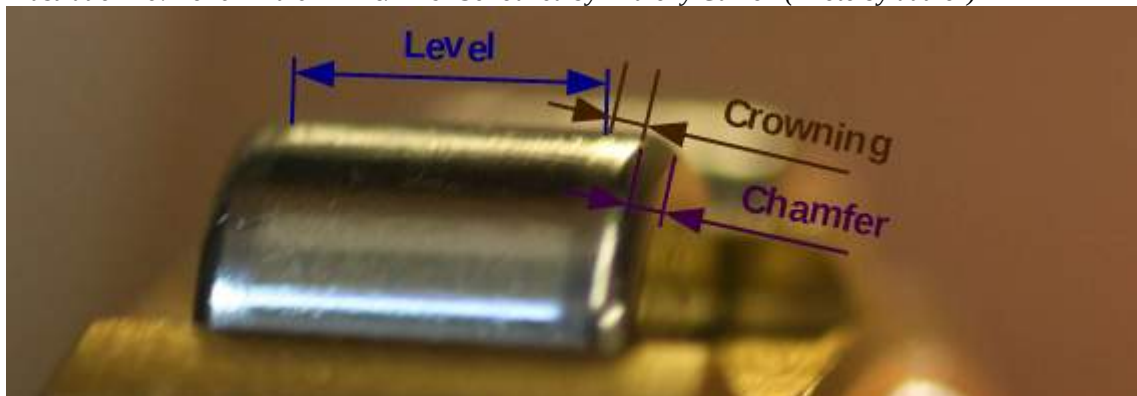


Illustration 9 shows the relative sizes of the rollers and illustrates how slight the crowning is for both bearing rollers. The crowning would be difficult to see by eye with the crown drop being around 0.035 mm (1.38 thou) for the R&M bearing and 0.015 mm (0.59 thou) for the FAG 306E. Both these bearings have rollers with a total crown drop which is equivalent to less than 1% of the maximum roller diameter. N.B. These diagrams are all based on JM Leadbeater’s measurements from the late 1970’s.

In addition a NOS RHP 6/MRJA30 bearing was photographed in detail by the author. The following annotated photograph shows the partial crowning of the roller which is the ‘blending’ that Norton gave some marketing ‘spin’ and came up with the name ‘Superblend’. ‘Superblend’ has no engineering definition:

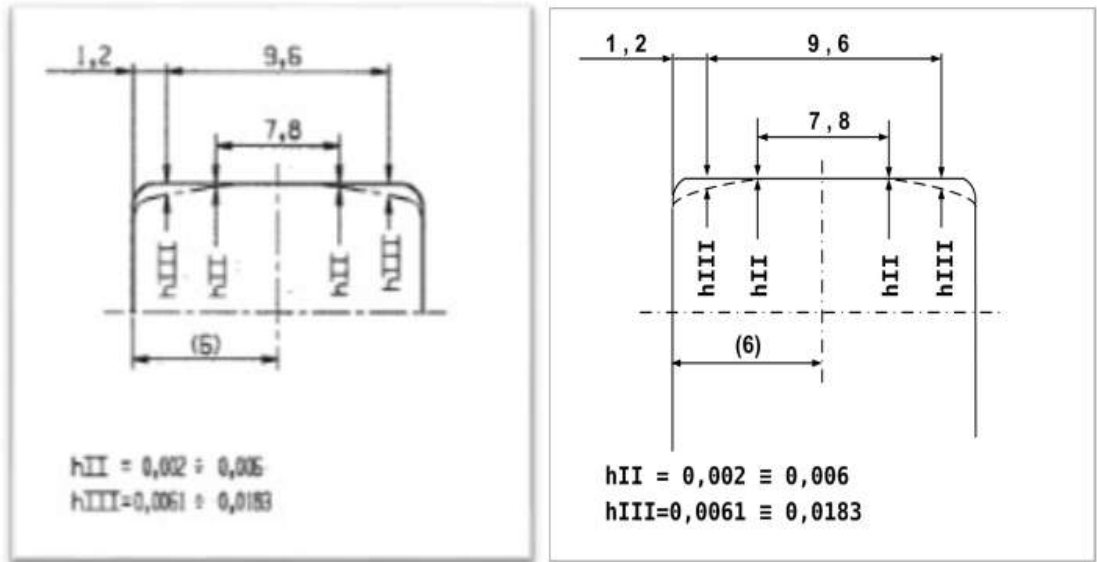
Illustration 10: Roller in the RHP 6/MRJA30 loaned by Anthony Curzon (Photo by author)



Additional photographs of the bearing which show the partial crowning are shown in Annex 8 on page 33 (Illustration 30). The author has only ever seen the ‘6’ hand engraved which is consistent with the bearing being a relatively short-lived special. Other longer-lived specials are not hand engraved, e.g. 8/MRJA30 as fitted to Triumphs (see Annex 8 on page 32 Illustration 29).

New information on the current FAG NJ306E has been obtained coincidentally by the author and by Les Howard (NOC member) from FAG [see Annex 3, Pg 23]. For reasons of commercial confidentiality FAG will not provide a full description of the roller profile but have provided a 'snippet' diagram as follows:

Illustration 11: 'Snippet' of current roller profile for NJ306E provided by FAG in 2016 (re-drawn copy also shown to improve clarity)



The drop from theoretical parallel, i.e. from horizontal, is measured at gage points hII and hIII. At hII the drop off from theoretical parallel is between 0.002 to 0.006mm and at hIII and the roller edge is between 0.0061 and 0.0183mm. The line of the curve is defined by a logarithmic function. FAG has also confirmed that the logarithmic profile is now 'pretty much standard for rolling bearings'. Turning to the bearing Jim Comstock removed from a 1974 850 Commando, snapshots are shown from the detailed measurements video [REF1]; Illustration 12 FAG NJ/NU306E with roller removed for measuring (see Table 4, Page 15 for explanation of NJ & NU), Illustration 13 Roller being measured and Illustration 14 Instrument display showing measured roller length and edge profile.

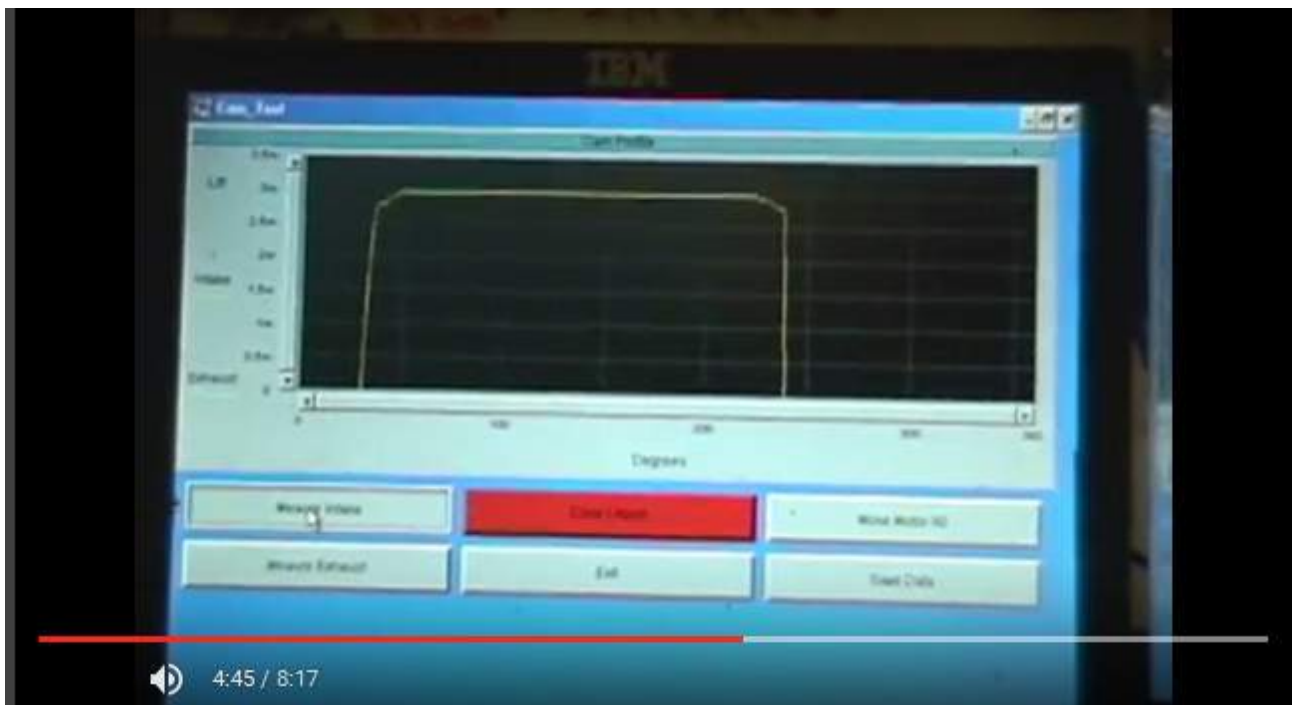
Illustration 12: FAG NJ/NU306E with roller removed for measuring (see Table 4, Page 15 for explanation of NJ & NU)



Illustration 13: Roller being measured



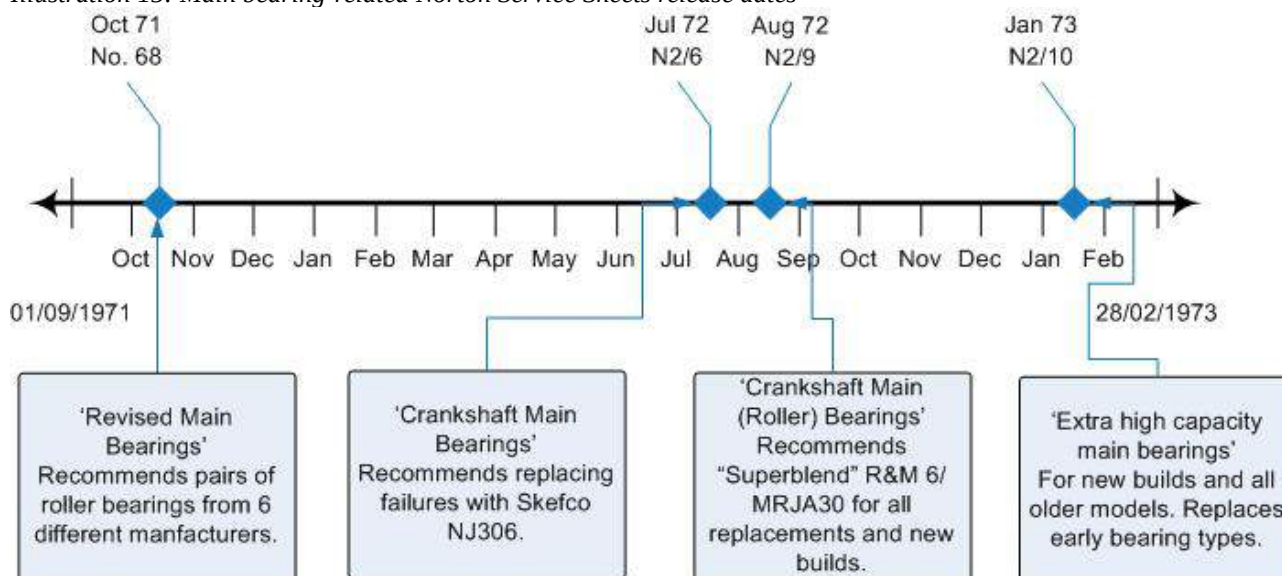
Illustration 14: Instrument display showing measured roller length and edge profile



The measurements in Table 1 for the roller straight part for an FAG NJ306E bearing do not match those of the bearing in Jim Comstock's measurement video. Scaling from the snapshot with a roller total length of 12mm indicates that the chamfered edge is 0.92 mm wide. No crowning is visible. Although there are fewer details than in later catalogues, there is a diagram of a bearing roller in [REF28] from 1966 on page 418. This shows a flat profile like that shown in Illustration 14 with a radiused chamfered edge. The y-axis in Illustration 14 is scaled from 0 to 3.5 thousandths of an inch and is marked in 0.5 thou increments. The roller is measured in 2 thou steps. Table 1 indicates 2mm length, i.e. (12 minus 8) divided by 2, for the crowned part and chamfer. Given the many specifications of bearings being tried by Norton in 1972-3 it is perfectly possible that the measurements in

Table 1 refer to bearings with different specifications but the same designation. There were 4 Norton Service Releases concerning main bearings issued during the period October 1971 to January 1973 (see Annex 4, page 24) so there was certainly a lot of activity at Norton to address the problems with a variety of changes. This is illustrated by the timeline of service sheet releases (Illustration 15). Designs are certain to have changed since the roller measurements were taken by JM Leadbeater, and could also be different for earlier bearings.

Illustration 15: Main bearing-related Norton Service Sheets release dates



Main bearing failure has been attributed to many causes including; the poor performance of the advance/retard unit, lack of lubrication caused by design changes, poor quality crankshaft manufacture and the general impact of higher states of tuning. Flexing of the crankshaft has always occurred. Norton had changed from ball bearing (timing side) and roller (drive side) main bearings to paired rollers in October 1971 (SR No. 68). However, the roller bearings specified – including FAG NJ306 (without the 'E') - generally had lower load ratings (25-30%) than later 'E' ones and had no 'crowning' to reduce loadings on the roller edges. The exception to this is the SKF NJ306E referred to in SR No. 68. The lower load capacity bearings along with the higher tuned 'Combat' engine and encouragement to rev it to 7000 rpm led to a large number of bearing failures which were widely reported in the motorcycle press at the time, e.g. Bike Magazine 1972 [REF40] and [REF41]. There is a detailed article on crank flexing in the Newsletter of the Northern California NOC [REF29]. Tracing the causes of bearing failure is not considered further in this paper. Table 2 summarises all of the available Norton service release sheets relating to Commando main bearings.

Table 2: Summary of Main Bearing Service Releases (see Annex 4, Pages 24 - 26 for full wording)

Release No.	Date	Ref to Bearings & Crankshaft	Engine No.	Retrofit
68 [Table 8, Page 24]	Oct 71	Revised main bearings (Pt No 063114). Refers to pairs of roller bearings. (Author's note - previously a ball bearing was used on the timing side). 063114 is a Ransome & Marles type MRJA30 roller bearing. 6 alternative bearings are also listed from SKF, FAG, NTN, Hoffman and RHP. All 2 dot or C2 fit. (See Table 8, Pg 24)	None specified but change introduced immediately in October 1971.	Not specified.
2/6 [Table 9, Page 25]	Jul 72	Recommends Skefco type NJ306, with a specified nominal internal clearance, as the replacement for any failures.	From 200004 affected. Nominal increase in bearing housing diameter from 207197.	1972 models
2/9 [Table 10,	Aug 72	Introduces 'Superblend' bearing R&M 6/MRJA30 (Pt No 063906).	Fitted from 211891.	Replaces 063114. May also be fitted

Release No.	Date	Ref to Bearings & Crankshaft	Engine No.	Retrofit
Page 25]				to 1971 and earlier.
2/10 [Table 11, Page 26]	Jan 73	New main bearing (Pt No 064118). <i>(Author's note – based on [REF6] assumed to be the FAG NJ306E which is supplied under this part number).</i>	None specified but all 850s were fitted with FAG NJ306E bearings according to NOC Service Notes.	Supersedes 063906. Fits to all models including prior to 1971.

It is disappointing that Norton did not give more details in the service sheets, e.g. no engine numbers in relation to Service Release Numbers 68 and 2/10. Also there is no manufacturer or bearing designation specified by Service Release 2/10. The NOC Norton Commando Service Notes [REF6] written in 1979 state, '*...the factory reckon only to use the F.A.G. bearings in the 830s...Only use bearings with one of the following nos: NJ306E (E is very important, NJ306 is weaker) or 6 MRJA30. The 6 may be hand engraved on the bearing.*'. So taking this at face value we can work on the assumption that all 850s were originally fitted with the FAG NJ306E bearing available at the time. For 750s from 211891 (August 1972) until the last 750 230935 (see REF6 pg. 3) built in October 1973 (see REF19 pg. 55) the original fitment started with the R&M (or RHP) 6/MRJA30 bearing but probably changed over to the FAG bearing sometime after January 1973 (the date of Service Release 2/10). The various part numbers used for main bearings for Commandos (1968-75) are shown in Table 12 on page 26.

The R&M (or RHP) 6/MRJA30 bearing has 13 rollers and the FAG NJ306E has 12 rollers. Both of these therefore have more rollers than the 11 of the NJ306 type (without the 'E') which was one of the types failing. Annex 5 on page 27 of this document lists the bearings likely to have been failing in 1972/3. It may be that the increased number of strengthened rollers alone reduced the incidence of failure of main bearings. Any existing main bearing in use with less than 12 rollers, and any with 13 rollers marked RHP MRJA30 or R&M MRJA30 (without the partial crowning indicated by the prefix '6'), would be more likely to fail than their later replacements.

A technical reference [REF11] sponsored by NASA, describes the effect of roller profile on cylindrical roller bearing life prediction. The terms 'blended' or 'profiled' are used with reference to the bearing edge on Page 13 of [REF11]. Logarithmic roller profile optimisation is covered in [REF12] from the bearing company NTN. This paper includes calculations and graphs of the loadings for different edge profiles.

Why did Norton change from the timing side ball/drive side roller bearing arrangement to paired roller bearings in 1971? Had main bearing failures already started to occur? The most likely reason was a recognition of the increased loadings on the main bearings, compared with the Atlas and Dominator engines, causing failures. For example, a roller bearing of the same size has a dynamic load rating of 61000N compared with 29000N for a ball bearing (FAG 2014 catalogue data). The article by TRS [REF20] indicates that main bearing failures were occurring at around 10,000 miles on models earlier than the highly tuned Combat Commando variant which incorporated several design changes.

The loading capacity of roller bearings has increased over time. See Annex 6 on page 28 for a summary. It is also the case that cylindrical roller bearing edge profiles have evolved over the years. This is referred to in Peter Williams's book *Designed to Race* [REF10] '*It was interesting in the following decades to observe the development of roller bearings from the roller 'barrelling' to a hyperbolic function, through a sinusoidal function, to the current logarithmic curvature.*' [REF22] from SKF refers to '*the introduction of the EC cylindrical roller bearings with modified roller end and flange contact surface*' in 1981 and '*The introduction in 1984 of the logarithmic profile of roller raceways*'. In Annex 4 (page 24) correspondence with FAG raises the possibility in one email of 'crowned' inner raceway profiles being supplied although in another email the correspondent thought this unlikely for the NJ semi-locating type of bearing. There is an ISO Technical Standard [REF26] relating to ISO 281 [REF14] which includes the equations for the logarithmic profile functions of cylindrical rollers. The standard also indicates that '*the profile functions...give approximate values. Actual roller designs, based on the expertise of the manufacturer, can deviate significantly from these reference geometries.*'

Graphs are shown on page 23 of [REF30] which show the stress distribution across bearing rollers of 6 different profiles at 3 different loadings. The advantages of a logarithmic roller profile in reducing edge loadings and spreading stress more evenly across the roller are clear.

As an additional check on the profile of the main bearings being supplied for Norton Commandos in 2016, a brand new FAG NJ306E bearing was purchased from RGM Norton and sent to Jim Comstock for measurement. This bearing has a date of manufacture of 13th July 2015 (see Illustration 16 and Illustration 17).

Illustration 16: Modern FAG NJ306E full designation (supplied by RGM Norton)

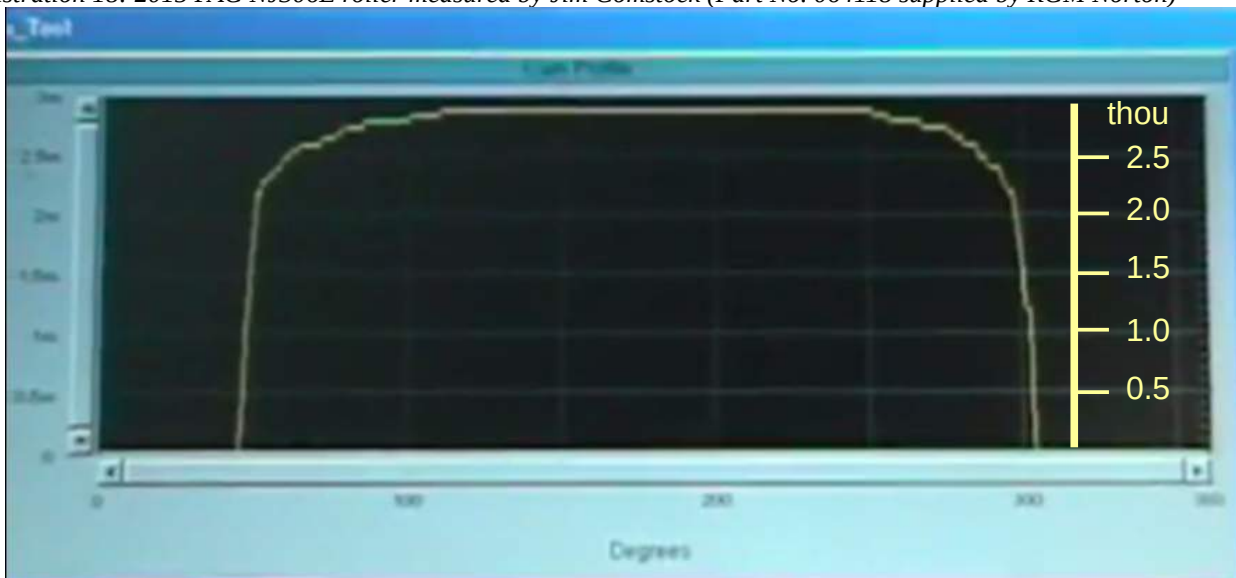


Illustration 17: FAG NJ306E Manufactured on 13/07/15, i.e. as marked 15071300



The resulting roller profile scan is shown in Illustration 18.

Illustration 18: 2015 FAG NJ306E roller measured by Jim Comstock (Part No. 064118 supplied by RGM Norton)



This clearly shows that the roller profile from 2015 is very different from that of the earlier FAG bearing measured by Jim Comstock [shown in Illustration 14] even though these had similar designations and were from the same manufacturer. Although the vertical axes differ (Illustration 18 has full scale at 3 thou versus 3.5 thou for Illustration 14) it is clear that the edges are curving over more of the 12mm total length – approx 2.5mm at each end – with a central parallel portion of approximately 7mm. The ‘crown drop’ measures approximately 0.018mm (0.7 thou). The bearing measured by JM Leadbeater [REF1] has a similar roller profile although it differs in detail with a parallel portion of 8mm vs 7mm and a crown drop of 0.015mm (0.6 thou) vs 0.018 (0.7 thou) for the 2015 bearing. However, the differences could be within the margin of error for measuring.

The current FAG NJ306E bearing is rated for much higher loadings of 61000/48000N dynamic/static versus 35800/31000N for the R&M/RHP 6/MRJA30. Equivalent fully barrel shaped roller bearings (e.g. FAG 20306) are available but would be unsuitable for this use due to lower load ratings of 49000/49000N and a revolution limit of 5000 vs 10000 rpm for the NJ306E. The fatigue load limit of the NJ306E is also nearly double that of the 20306 at 8000N versus 4250N. (All FAG data from [REF7]).

The snippet diagram and the instrument image both exaggerate the curvature of the FAG bearing. The highest value in FAG’s diagram shows the crown drop at 0.0183 mm (0.72 thou) which is equivalent to a 0.3% narrowing of the maximum roller diameter. You’d be hard pushed to spot the curvature with the naked eye except within the last 0.7-0.8mm as is clear in this photograph [Illustration 19]:

Illustration 19: Roller from 2015 NJ306E bearing



For comparison purposes the scans of the roller profiles of the MRJA30, 6/MRJA30 and FAG NJ306E (1974) and NJ306E (2015) are shown below.

Illustration 20: Roller profile comparison standard R&M/RHP; MRJA30 (left) and 6/MRJA30 ‘superblend’ (right)

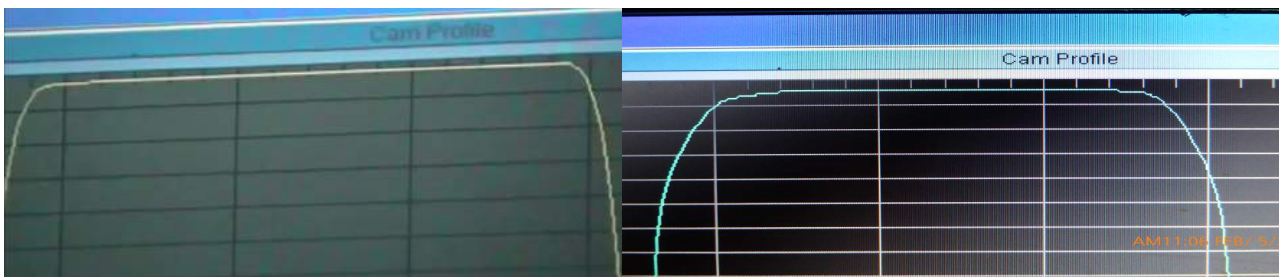


Illustration 20 shows the roller profile of the standard R&M/RHP MRJA30 bearing on the left (dynamic load rating 41,900N). The roller profile of the special ‘superblend’ bearing 6/MRJA 30 (dynamic load rating 35,800N) is shown on the right. The additional partial crowning of the 6/MRJA30 roller edges is clear. The crowning helps with roller edge loading but decreases the overall dynamic load capacity.

The standard MRJA30 (without the ‘6’ prefix which indicates a ‘special’ bearing) was the bearing fitted under part number 063114 when Norton introduced paired rollers (timing and drive side) in Service Release 68 dated October 1971. This was one of the types failing. It was almost certainly also the bearing usually fitted on the drive side only under the earlier part number NM17822.

Illustration 21: Roller profile comparison standard FAG; NJ306E 1974 (left) and standard NJ306E 2015 (right)

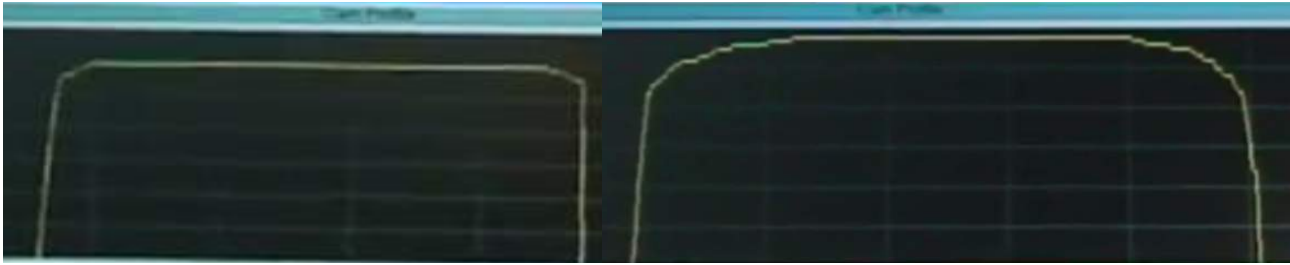


Illustration 21 shows the roller profile of two standard FAG NJ306E bearings. The 1974 bearing has a dynamic load rating of 51,000N. Over the intervening 41 years the roller profiles have developed and changed. The 2015 roller profile is known as 'logarithmic' and reduces edge loadings on the rollers. It has a dynamic load rating of 61,000N. In many ways the original R&M/RHP 'superblend' 6/MRJA30 and the latest FAG bearing are using a similar technique to tackle the edge loading problem. However, both the FAG bearings are rated for much higher loadings than the R&M/RHP bearings and both are completely standard. The illustrations are included to show the shape of the roller profile and are not all to the same scale, e.g. the R&M/RHP bearing rollers are 9.53mm long whereas the NJ306E rollers are 12mm long. The vertical axis of the screen grids has intervals of 0.5 thousandths of an inch.

Suitability & Availability

As far as it is possible to tell the R&M/RHP 6/MRJA30 and FAG NJ306E bearing types are both 'up-to-the-job' in practical use (see NOC Commando Service Notes Page 16 [REF6] for recommendation).

The R&M/RHP 6/MRJA30 bearing is difficult to obtain and also expensive (>£100). Currently a bearing with this designation is obtainable from Orinoco Bearings Ltd of Leeds (www.ransomeandmarles.co.uk). There may be other suppliers. There is no obvious reason why Norton changed from this bearing to the FAG NJ306E. The R&M/RHP bearing was a 'special' variant and was therefore probably more expensive to supply than the standard NJ306E. The proximity of Norton engine manufacturing at Marston Road, Wolverhampton and FAG less than 6 miles away at Wombourne may also have been a factor.

The latest FAG bearing NJ306E is widely available, e.g. in the UK from Andover Norton, Norvil, RGM and others. The bearing is supplied under the Part Number 064118 (as in Service Release N2/10). The bearing normally supplied has the full designation FAG NJ306-E-M1-C3.

Standards

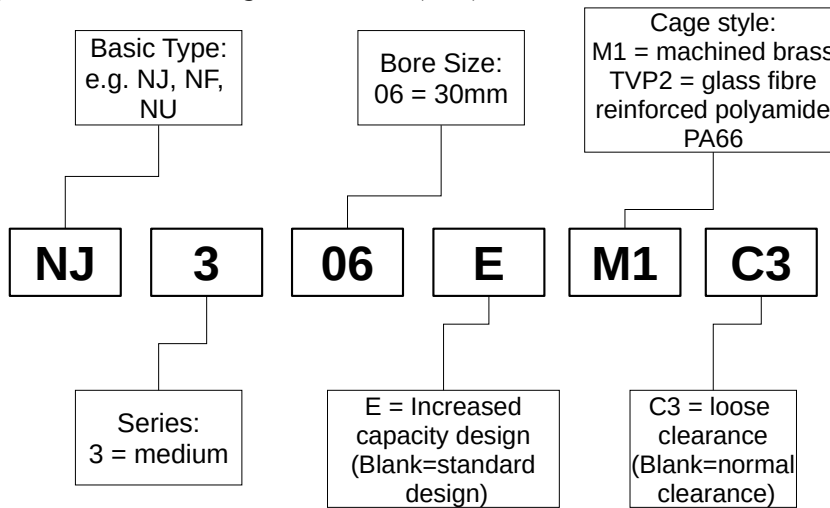
During the research for this document the author also tried to find out which international standards applied to the modern FAG bearing. FAG documents refer to a range of ISO and DIN standards. The information in the following Table 3 was included in an advert on Amazon.com for an FAG NJ306-E-M1-C3 bearing:

Table 3: Standards applying to an FAG NJ306-E-M1-C3 bearing

Bearing Characteristic	Applicable Standard	Reference
Main bearing dimensions	DIN 5412-1	[REF13]
Basic dynamic load ratings	DIN ISO 281	[REF14]
C3 radial internal clearance	DIN 620-4 (ISO 5 753)	[REF15]
Shaft and housing tolerances	ISO 286	[REF16]
Through-hardening steel for inner and outer rings	ISO 683-17	[REF17]
System for creating part numbers for rolling bearings	DIN 623-1	[REF18]




The terminology for the bearing designations, e.g. suffixes, is covered by DIN 623-1. The table of standards (Table 3) has been checked for references in FAG documentation (Catalogue and Tech Paper) and found to be correct. Illustration 22 shows the designation nomenclature for FAG bearings as applied to the NJ306E.

Illustration 22: Cylindrical roller bearing nomenclature (FAG)



The first suffix E of the full bearing name refers to bearings having a higher capacity roller set and are thus designed for very high load carrying capacity (see FAG catalogue [REF7] page 397). The suffix M1 relates to the bearing cage material. M1 indicates a solid brass cage, two-piece, roller guided. An alternative FAG type has the suffix TVP2 indicating a solid window cage made from glass fibre reinforced polyamide PA66. See Annex 7 on page 29 for further information on TVP2 cages. There is no evidence that a bearing with a TVP2 cage would be unsuitable for this application. The C3 suffix refers to radial clearance larger than normal (see FAG catalogue page 399). The roller bearing basic types referred to here are shown in Table 4:

Table 4: Raceway configurations for roller bearings referred to.

Raceway Configuration	Basic Type & Description
	NF - Rollers attached to the inner race with a loose outer race with a lip on one side. R&M 6/MRJA30 bearing is of this type.
	NU - Rollers attached to the outer race with a loose inner race. This description is included because the outer races for Type NU and Type NJ are identical. Some bearings have been fitted to Commandos with an outer race marked NU and an inner race marked NJ. This results in an overall NJ configuration. A fully NU configured bearing would not be suitable for a Norton Commando.
	NJ - Rollers attached to the outer race with a loose inner race with a lip on one side. FAG NJ306E bearing is of this type.

Other manufacturers

For manufacturers other than FAG nomenclature can vary. For the elements and suffixes shown in Illustration 22 the cage style is the most likely to vary. Other specifications, e.g. loadings, may also vary.

I have concentrated on the FAG bearing here, but it is perfectly possible for other manufacturer's bearings to be suitable for this application. The widespread manufacture of bearings to national and international standards increases the likelihood of this. For a possible candidate example see the SKF Catalogue [REF8] page 606. The Norton Owners Club of New South Wales also refers generically to main bearings from other manufacturers on their website <http://www.nocnsw.org.au/technical/commando-bearings>. This information is not new. [REF3] on the NOC website includes postings, particularly towards the end of the list, that are consistent with much of what is concluded in this paper.

Looking back over 40 years on at the Norton Service Sheets it is interesting to note how Norton went from recommending main bearings from 6 different manufacturers in 1971 [Table 8, Page 24] to specific bearings from individual manufacturers just 8 months [Table 9, Page 25] and 9 months [Table 10, Page 25] later.

Searches of eBay and Amazon at the time of drafting this paper yielded an RHP bearing (successors to R&M)

designated NJ306ETN with a polyamide cage and 13 rollers, an NTN bearing designated NJ306E C3 with 12 rollers and a brass cage and an NSK bearing designated NJ306ET with 12 rollers and a polyamide cage. All of these bearings were listed under OEM part number 064118 and all were termed 'Superblend'. Indeed these bearings were found using the search term 'Superblend'.

Sourcing bearings directly from the internet can be problematic unless using reputable suppliers who know their supply chains. There are some unscrupulous companies either knowingly, or unwittingly, supplying counterfeit bearings. The fakes can be very good imitations and difficult to tell apart from the genuine article.

The life of the term 'Superblend'

The term 'Superblend' is first referred to in Service Release N2/9 of August 1972 and originally applied only to the R&M or RHP 6/MRJA30 bearing. The term was not repeated in Service Release N2/10 of January 1973 which, as far as it is possible to tell, introduced the FAG NJ306E bearing. It was an FAG NJ306E configured bearing, albeit that the outer race was marked NU type (see Table 4, page 15), that Jim Comstock removed from a low mileage Commando 850 for measurement. The outer bearing ring type is identical for NJ and NU type bearings.

No doubt there were press releases and briefings at the time referring to the new main bearings but these are not available to the author. What is still available are paper copies and pdf files of scanned images of the original Norton Commando sales brochures, e.g. [REF38]. These were examined for references to main bearings. Mentioning the type of main bearings seems an unlikely selling point, but there are references. The findings are shown in Table 5.

Table 5: References to main bearings in Norton Commando Sales Brochures (1969-75)

Year	Text in Engine Section of Brochure Referring to Main Bearings
1969-71	No reference
1972	'Roller main bearings.'
1973 & 74	'High capacity superblended large diameter roller main bearings.'
1975	'High capacity roller main bearings.'

The first reference is in the 1972 brochure which is when the first paired roller main bearings were introduced following Service Release 68 (Oct 1971). 1973 has the first reference to 'superblended' and follows the Service Release N2/9 (Aug 1972). The reference to 'large diameter' looks to be a case of Norton being 'liberal with the truth' since the FAG NJ306E had larger rollers than the 6/MRJA30 but only the latter was 'superblended'. By 1974 Service Release N2/10 (Jan 1973) had introduced the FAG NJ306E but the 'superblended' wording remained. By the time of the 1975 brochure the term had been dropped.

Illustration 23: Norton Commando brochure extracts; 1972, 1973, 1975 (left to right)

The illustration shows three columns of text from Norton Commando brochures. The first column (1972) describes the engine and lists specifications: Capacity 745 c.c. (45 cu. ins.), Bore 73 mm (2.88 ins.), Stroke 89 mm (3.5 ins.), Compression Ratio 9:1, Max. cruising r.p.m. 7,000, B.H.P. at sea level 6,800 r.p.m. The second column (1973) describes the engine and lists specifications: Capacity 828 c.c. (50 cu. in.), Bore 77 m.m. (3.03 in.), Stroke 89 m.m. (3.5 in.), Compression Ratio 8.5:1, Maximum r.p.m. continuous cruising 5,900. The third column (1975) describes the engine and lists specifications: Displacement—828cc, Bore and Stroke—77 x 89mm, Compression Ratio—8.5:1, HP @RPM—Max. @5900. The 1972 and 1973 extracts have yellow highlights around the phrases 'Roller main bearings' and 'High capacity superblended large diameter roller main bearings' respectively. The 1975 extract has a yellow highlight around 'High capacity roller main bearings'.

Some other contemporary and reference documents available to the author were also examined and yielded the following [Table 6]:

Table 6: Other Reference Documents

Id	Reference	Relevant Extract
1.	Book by Roy Bacon 1990 [REF19] Page 38	<i>'The answer was the Superblend bearing which was a roller race with each roller having a slight barrel form at each end.'</i>
2.	Motorcycle Sport Jan 1977 [REF20] Page 28 'spooof' article by TRS	The bearing people said...'How about a bearing, they said, which is straight in the middle and barrel shaped at the ends?'
3.	Bike Magazine May 1975 [REF21] Page 37. Review of Norton Commando 850 Mk3	<i>'The adoption of FAG Superblend bearings, the rollers of which have a slight taper thus eliminating line contact, overcame the problem and now even the crank has been beefed up.'</i>
4.	NOC Norton Commando Service Notes 1979 [REF6] Page 5	<i>'...and stronger main bearings fitted, i.e. Superblends (barrelled rollers).'</i>
5.	Norton Commando (Haynes Great Bikes) 2004 by Mick Duckworth [REF25]	<i>'From July 1972, the scandalously high main bearing wear rate was addressed during original engine building by fitting a unit in which the rollers were slightly barrelled in form. This type of bearing, known as Superblend and already familiar with NV's senior engineers, this allowed for a flexure of the crankshaft without edge-loading of the rollers.'</i>
6.	Bike Magazine Autumn 1972 Page 5. 'Roll Over Andover' in Ride On section REF27	<i>'Called Superblend' the bearings being experimented with have rollers that are tapered at their ends, rather than the simply radiused edges of the present ones. This gives a stronger load capacity and when eventually produced, should clear up an embarrassing complaint for the Andover lads.'</i>
7.	Motor Cycle, 8 March 1973. Norton Special, 'Andover's Big Secret'. 850 Commando REF44 (Images of article from NOC member Julian Wells.)	<i>'Changes start at the crankshaft. The flywheel is wider than for the 750 cc version, and a major feature is the adoption, at both ends of the shaft, of Fischer AG main bearings with spherical-edge rollers. The new bearings, which have heavy, brass casings, are claimed to have 25 per cent more load capacity than normal roller bearings. Their housings in the crankcase castings are line-bored.'</i> Motor Cycle Edition 8/3/1973.

It is noticeable how the 1st, 2nd and 5th references mention bearing rollers as *barrel form/shape...at the/each end*. The 3rd and 6th mention a *taper/slight taper*² which for the 4th reference is *barrelled*. The 7th reference uses 'spherical edge' which implies an FAG 'special' - although there is no evidence for this. However, reference to 25% more load capacity is very close to the difference between the dynamic loads of the earlier FAG NJ306 bearing and the later NJ306E as fitted to all 850s. Could the whole notion of *barrel shaped* perhaps simply be 'shorthand' to describe the slight narrowing or partial crowning of what is a mainly cylindrical bearing roller, the 6/MRJA30? Describing the rollers as barrel-shaped is an exaggeration. The 'special' characteristics of the R&M/RHP bearing at the time would be best described, using bearing terminology, as those of a 'partially crowned cylindrical roller bearing'.

Norton solved the main bearing problem by using one special (6/MRJA30) and one stronger standard bearing (NJ306E). Longer term they developed the 850 engine with a lower state of tune and lower cruising rpm of 5900 (see Illustration 23).

The term 'Superblend' has persisted but really only applies to the original R&M/RHP bearing. FAG have indicated that they did not recognise the term (see Annex 3) yet it continues to be used widely alongside the main bearing part no. 064118 and I've also seen it applied (incorrectly) to the Commando gearbox layshaft bearing. Norton also tried the term "Superplus bikes" to describe the 1973 850 range. That one didn't catch on. My feeling is that the term 'Superblend' is a marketing master stroke from the 'Super Seventies' that will still be around a long time after we've all been on our last ride-out. Others have also referred to 'Superblend' as a marketing ploy, e.g. Bob Stafford [REF37].

2 Tapered roller bearings are a specific type of roller bearing as are barrel roller bearings (see [REF7] and [REF42]). Neither of these two types have ever been recommended by Norton for use as main bearings (see [REF39] and Annex 4).

Conclusions

As a Norton Commando owner I am naturally pleased that reliable replacement main bearings are widely available and that main bearing types likely to fail can be identified if the engine is dismantled. Any main roller bearing with less than 12 rollers is worth replacing. It is also clear which engine numbers were originally fitted with suitable main bearings, i.e. all 750s after engine number 211891 and all 850s. There are also alternative manufacturers of suitable replacement roller main bearings and there is no evidence that bearings with reinforced polyamide roller cages would be unsuitable for this application.

Based on the available evidence, the original bearings designated 'Superblend' never had barrel-shaped rollers nor have any successor types ever had barrel-shaped rollers.

Concerning the term 'Superblend', this has no engineering definition and its use has become increasingly ambiguous in its application to bearings with varying specifications. Discussions about main bearings would be better based on bearing specifications, at the time of manufacture, and manufacturer's designations and data. In my opinion the term 'Superblend' just 'gets in the way'.

It is my personal view that 'Superblend' should be consigned to history where it best belongs. I also realise that given its place in Norton folklore that this is unlikely to occur.

Andrew Heathwood, Devon, UK. March 2018

The opinions expressed here are solely my own and do not represent the views or opinions of the Norton Owners Club or the Access Norton Forum. This document contains information only and the author is not, by means of this document, rendering advice or services. Before making decisions and actions based on this document you should consult an appropriately qualified engineer. The document is provided as is, and the author makes no express or implied representations or warranties regarding it. Your use of any information contained in this document is entirely at your own risk. A summary of the findings of this document have been included in two articles in the Roadholder [REF45], [REF46] and on the Real Classic website <https://www.real-classic.co.uk/2018/02/15/classic-techniques-superblend-bearings-part-one/> et seq.

Acknowledgements

Thanks are due to the reviewers of earlier drafts of this document; J Comstock, 'Kommando', 'L.A.B.' and J.M. Leadbeater (all Access Norton Forum), John Dunn (Norton Owners Club, Technical Support – Commandos) and John Holmes (NOC member). Also to Les Howard (NOC member) for sharing correspondence with FAG. Special thanks are due to Jim Comstock for his initiative and continued help in measuring bearing rollers, to J.M. Leadbeater (NOC member and aka 'Beltdriveman on the Britbike forum) for having the foresight to record details and take measurements in the late 1970s and to Anthony Curzon (NOC member) for spotting and loaning the NOS RHP 6/MRJA30 bearing. Thank you also to those who gave permission to use photographs and images. The provision of new information from Mr Neil Wright (Product Engineer at INA FAG) is gratefully acknowledged as is the provision *gratis* by FAG of a hardback copy of their 2014 rolling bearing catalogue. Chris Grimmett kindly brought the measured modern FAG bearing back from the 2016 INOA rally in California. Thanks are also due to Dougie Muir for supplying scans of pages from NOC Roadholder (issues 193 and 194) and to the NOC Librarian who provided extracts from Mick Duckworth's book [REF25].

References

Reference No.	Reference details or hyperlink ³
REF1	https://www.accessnorton.com/NortonCommando/superblend-bearing-profile.20328/
REF2	http://www.nortonownersclub.org/support/technical-support-commando/commando-main-bearings-service-releases
REF3	http://www.nortonownersclub.org/support/technical-support-common/crankshaft-main-bearings
REF4	http://www.nortonownersclub.org/support/technical-support-commando/superblend-main-bearings
REF5	https://www.accessnorton.com/NortonCommando/superblend-installation.4281/
REF6	Norton Owners Club Commando Service Notes by Tim Stevens and John Hudson. Editor Alan Osborn. 48 pages. 1979. Page 16.

³ Hyperlinks included here all worked at the time of publication. The author cannot be held responsible for hyperlinks which no longer work. Certain links may lead to websites or resources maintained by third parties over whom the author has no control. The author makes no express or implied representations or warranties whatsoever regarding such websites and resources, and links to any such websites and resources should not be construed as an endorsement of them or their content by the author. Linking to such third party websites from this document will be entirely at your own risk.

Reference No.	Reference details or hyperlink
	<i>Authors Note: I have relied heavily on this reference and the official contemporary Norton Commando Service Sheets REF39. Tim Stevens and John Hudson were both former Norton employees highly experienced in dealing with the practicalities of the main bearing problems in 1972/3. Writing just a few years later in 1979 means that the information used is highly likely to be accurate, e.g. bearing types, markings and designations.</i>
REF7	FAG Rolling Bearings Catalogue HR1 Schaeffler Technologies April 2014
REF8	SKF Catalogue Rolling bearings PUB BU/P1 10000/2 EN August 2013 1380 pages.
REF9	Technical Information TI No. WL 43-1190 EA October 1999 FAG Rolling Bearings Fundamentals · Types · Designs. Pg. 5.
REF10	Williams , Peter (2012-05-08). Designed to Race - Peter Williams (reference to rollers at Kindle Location 3219-3220). Brooklands Books. Kindle Edition. (Pg 166 in book 2 nd Edition).
REF11	Effect of Roller Profile on Cylindrical Roller Bearing Life Prediction by Joseph V. Poplawski, Erwin V. Zaretsky, Steven M. Peters. NASA/TM-2000-210368, Glenn Research Center August 2000. 34 pages.
REF12	NTN TECHNICAL REVIEW No 75 (2007). Logarithmic Profiles of Rollers in Roller Bearings and Optimization of the Profiles by Hiroki Fujiwara and Tatsuo Kawase. 9 pages.
REF13	DIN 5412-1 Rolling bearings - cylindrical roller bearings - Part 1: Single row with cage, separate thrust collars by Deutsches Institut Fur Normung E.V. (German National Standard), 01/08/2005
REF14	DIN ISO 281 Rolling bearings - dynamic load ratings and rating life, 01/10/2011
REF15	DIN 620-4 (ISO 5 753) Tolerances for rolling bearings - Part 4: Radial internal clearance by Deutsches Institut Fur Normung E.V. (German National Standard), 01/06/2004
REF16	ISO 286 System of limits and fits
REF17	ISO 683-17 Heat-treated steels, alloy steels and free-cutting steels - Part 17: Ball and roller bearing steels 15/10/2014
REF18	DIN 623-1 Rolling bearings; fundamental principles; designation, marking standard by Deutsches Institut Fur Normung E.V. (German National Standard), 05/01/1993
REF19	Norton Commando, All Models by Roy Bacon. Niton Publishing 1990. ISBN 1 85648 310 X. Reprinted by Selecta Book Limited in 1995. Page 38.
REF20	Motorcycle Sport January 1977, Volume 18, Number 1, Ravenhill Publishing Company Limited, London. Pages 27-28. Article by TRS 'Vicious Circle, A cautionary tale...'
REF21	Bike Magazine, May 1975, Review of Norton Commando 850 Mk3. East Midland Allied Press Limited, Peterborough. Page 37.
REF22	100 YEARS EVOLUTION – of cylindrical roller bearings, 2 September, 2009. 'Evolution - the business and technology magazine from SKF (WWW.SKFCOM)'
REF23	Rolling-Element Bearings by Bernard J. Hamrock and William J. Anderson. NASA Reference Publication 1105 June 1983. Page 12, Figure 12.
REF24	Tolerance Design of Logarithmic Roller Profiles in Cylindrical Roller Bearings by Fujiwara, H and Yamauchi, K, Journal of Advanced Mechanical Design, Systems and Manufacturing Vol 4, No.4, 2010 Pages 728-738.
REF25	Norton Commando (Haynes Great Bikes) by Mick Duckworth. Published by J H Haynes & Co Ltd; First Edition edition (17 Mar. 2004) ISBN-13: 978-1844250219.
REF26	ISO/TS 16281:2008(E) Rolling bearings — Methods for calculating the modified reference rating life for universally loaded bearings. First edition 2008-06-15.
REF27	Bike Magazine, Autumn 1972, 'Roll Over Andover' item in Ride On section. National Magazine Co. Ltd, London. Page 5
REF28	FAG Ball and Roller Bearings Catalogue 41 000E, FAG Wolverhampton, 15 April 1966, 412 pages. Page 202 for NJ306E, Page 192 for NJ306.
REF29	Norton Notice, Newsletter of the Northern California Norton Owners Club, No. 219, October 1996,

Reference No.	Reference details or hyperlink
	Pages 7-9.
REF30	Effect of Roller Geometry on Roller Bearing Load-Life Relation by Fred B. Oswald, Erwin V. Zaretsky and Joseph V. Poplawski, NASA/TM—2015-218895, 34 pages. Pages 5 and 6.
REF31	RHP General Bearings Division Catalogue, October 1972, Publication LC500 10.72, 234 pages.
REF32	TI Nr. WL95-4E, FAG Rolling Bearing Cages, Designation·Design·Material, August 2000, 19 pages.
REF33	Temperature and Lubrication of the Norton Motorcycle Engine. Originally published as a series of articles in the Norton Notice, (the monthly magazine of the Norton Owners Club of Northern California). http://members.aol.com/NortonClub ©1993-2000 by Alan Goldwater. All rights reserved.
REF34	http://www.nortonownersclub.org/noc-chat/technical2-heavy-twins-forum/1004009?b_start=0#311375930
REF35	Roadholder Magazine of the Norton Owners Club, No 193 May/June 1997, Page 23.
REF36	Roadholder Magazine of the Norton Owners Club, No 194 July/August 1997, Pages 18-19.
REF37	Roadholder Magazine of the Norton Owners Club, No 164 July 1992, item author Bob Stafford (referred to in letter by Charley Osterley in [REF36]).
REF38	http://www.classicbike.biz/Norton/Brochures/Brochures.htm
REF39	Commando Service Sheets on Norton CD Edition 5 Heidelberg Desktop Publishing ('Kim the CD Man'), e.g. http://www.britcycle.com/Products/150/Contents_Norton_5.pdf
REF40	Bike Magazine, Early Summer 1972, 'Interstate into Europe'. National Magazine Co. Ltd, London. Pages 7-11.
REF41	Bike Magazine, Summer 1972, Letters. National Magazine Co. Ltd, London. Page 7.
REF42	Modern Tribology Handbook, Chapter 28, Rolling Element Bearings by Xiaolan Ai (The Timken Company) and Charles A. Moyer (The Timken Company, retired), 2001 by CRC Press LLC.
REF43	Ball and Roller Bearings. Ransome & Marles Publication No. 42, Issue 5. (Publication date not stated)
REF44	Norton Special, 'Andover's Big Secret'. 850 Commando. Motor Cycle, 8 March 1973, pages 11-19.
REF45	'Superblend – What's in a name?' Article in Roadholder (The Magazine of the Norton Owners Club) Issue No. 352 April 2017, pages 27-32.
REF46	'Superblends – the last word?' Article in Roadholder (The Magazine of the Norton Owners Club). Issue No. 366 June 2018 (<i>scheduled issue and date at time of writing</i>).

Change Log

Date	Version	Summary of changes
5/3/2017	1.0	Released version.
11/4/2017	1.0a	Change to author's Access Norton Forum username on page 1.
16/3/2018	1.1	Document updated following examination of NOS RHP 6/MRJA30 bearing with images and roller scan. Access Norton hyperlinks updated. Additional extract from NOC Commando Service Notes and new references REF43, REF44, REF45 and REF46. Minor corrections to abstract and detailed measurements. Addition of images of 2015 FAG NJ306E markings. Addition of SKF NJ306 image.

Bearing Dimensions

Rowson & Marles 8MRTA30.
11 rollers.



Width 11.12mm
O.D. 11.12mm.

Load capacity. Dynamic 4,900. Static 35,200N.

Rowson & Marles 6MRTA30.
13 rollers.

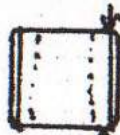


Width 9.53mm
O.D. 9.53mm

Load capacity. Dynamic 35,800N. Static 31,000N. 6mm Approx 1/4 section

4

FAG NT306E
12 rollers.



Width 12mm
O.D. 11mm

8mm Approx 1/4 section

Dynamic 51,000 : Static 48,000.

Annex 2 – Barrel-shaped roller bearings

Illustration 24: Example of a barrel-shaped roller with a fully convex edge



(Image part of a photograph supplied by K Glassborow, NOC member. Background edited)

This type of roller is from a bearing known as either a 'barrel', 'fully crowned' or 'spherical (when used in a double row) roller bearing.

The properties of cylindrical and barrel roller bearings with similar dimensions are shown in Table 7.

Table 7: Comparison of FAG cylindrical and barrel roller bearings (data from REF7)

FAG Bearing	Inner Diameter (d) mm	Outer Diameter (D) mm	Width (B) mm	Dynamic Load N	Static Load N	Fatigue Limit Load N	Limiting Speed min ⁻¹
NJ306E (cylindrical roller)	30	72	19	61 000 ⁴	48 000	8000	10 000
20306 (barrel roller)	30	72	19	49 000	49 000	4250	5000

The loadings are lower for the barrel roller bearing except for the static load which is slightly lower for the cylindrical roller bearing. The limiting speed of 5000 rpm for the barrel versus the cylindrical bearing makes the barrel bearing entirely unsuitable for a Norton Commando which usually revs to 6-7000 rpm. Available data closest to the 1970s is in [REF28, pages 244 & 245] which indicates a limited bearing speed under oil lubrication for bearing 20306 of 4500 rpm. This further confirms its unsuitability for this application.

According to FAG (REF7, Page 559), barrel roller bearings are designed to deal with high radial shock type loads and where radial misalignments have to be compensated. They only have a relatively low axial carrying capacity.

⁴ This is the dynamic loading given in the 2014 FAG Catalogue. This is higher than the value in Table 1 which is a contemporary value from the 1970s.

Annex 3 – Extracts of email responses from FAG

Sent: Friday, 11 March 2016, 14:16

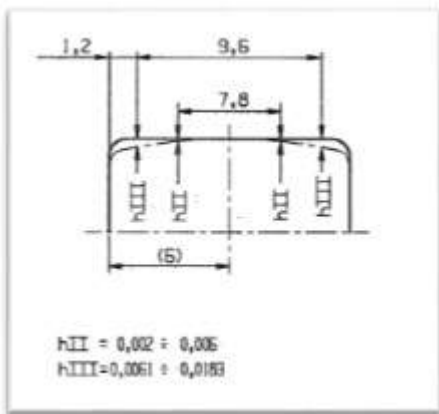
Subject: FW: Norton Owners Club Profile of a roller from a FAG NJ306E bearing

Hello Andy

I have had a very similar question on FAG brg NU305-E-M1, from Mr. Les Howard @ Norton Owner's Club, however I guess your questions may be related as he too was requesting clarification as to the roller / raceway profile.

With reference to FAG cylindrical roller bearing NJ306-E-M1-C3 refer to attached assembly drawing.

Due to confidentiality reasons I am unable to supply a detailed drawing of the rolling element used in this bearing, refer to the following drawing snippet that details the roller diameter profile;



Profile of roller ZRO11x12-QP-...-

Essentially all rolling bearings have a rolling element with a profiled form, this is so as to prevent 'edge loading' during high load or misalignment. As you will see from the sketch above this profile is determined by measuring the *drop-off* at various 'gaging points'.

I suspect that during the early to mid 1970's FAG would have supplied a version of this bearing with a slightly crowned inner ring raceway (identified with the additional suffix; ...BL), this allowed slightly more misalignment capability hence preventing damage by crankshaft flexing during high load. Norton coined the term ' Superblend' even so this was never recognised by FAG locally when Norton or respected spares supplier ordered the bearing.

...

Regarding the roller profile 'drop off';

hII @7,8/2 from its centre point, the drop off from theoretical parallel is 0,002 to 0,006mm

hIII @1,2mm and +9,6mm the drop off from theoretical parallel is 0,0061 to 0,0183mm

These features are detailed this way as in general the rolling element is inspected with pre-set 'DTI - snap gauges'.

You are right, this logarithmic profile is pretty much standard for rolling bearings even to this day.

Unfortunately will be very difficult (if not impossible) to find any documented knowledge of supply in 1970's, speaking to one of my Applications Engineers, who has approximately 40 years experience with FAG, he is telling me historically (prior to the 'E' design, and I would say this is from the late 1970's / early 1980's) where applications resulted in failures due to edge loading they would offer the version N_... -...- BL (profiled raceway on the inner ring).

However as an additional thought, is its very costly to produce a profiled raceway on a semi-locating (ribbed) inner ring, for this reason I guess there were never supplies for this variant as apposed to the NU...-BL (non-locating brg!)

Neil Wright

Product Engineer

INA FAG, Schaeffler (UK) Ltd

Annex 4 – Known Service Releases for Main Bearings & Related Part Numbers

(The first 3 service releases are shown in [REF2] and are also in [REF39] along with N2/10 in a fuller list.)

Table 8: Text of Norton Service Release No. 68 (October 1971)

Service Release No. 68													
Nature of Release	Revised main bearings												
Models Affected	All years and models of Commando												
Distribution	Worldwide												
Explanation													
<p>We are introducing a new roller main bearing arrangement in production almost immediately. The fitting of this bearing arrangement reduces overall width between the main bearings and increases timing side main bearing journal diameter.</p> <p>For service purposes we shall in future supply only the crankshaft of the latest size, Part No. 063106. The main bearings, Part No. 063114, must be used in conjunction. The new bearings are 2 dot single lip roller bearings and should be assembled with the lip into the crankcase in both cases. Main bearing Part No. 063114 is of the Ransomes type (R&M) MRJ A30. Alternative bearings which may be used are listed below:-</p> <table style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: left;">Manufacturer</th> <th style="text-align: left;">Type</th> </tr> </thead> <tbody> <tr> <td>S.K.F.</td> <td>NJ306 or NJ306E</td> </tr> <tr> <td>F.A.G.</td> <td>NJ306</td> </tr> <tr> <td>N.T.N.</td> <td>NJ306</td> </tr> <tr> <td>Hoffman</td> <td>R306L</td> </tr> <tr> <td>R.H.P.</td> <td>NF306</td> </tr> </tbody> </table> <p style="text-align: center;">All bearings to be 2 dot or C2⁵</p> <p>Note in fitting that NJ type bearings have the rollers and cage assembled to the outer race so that the outer can be pressed into the crankcase either way around. The inner race must be pressed onto the crankshaft with the lip leading. The NF type bearings have the rollers and cage assembled to the inner race. The outer race must be pressed into the heated crankcase with the lip leading. The inner race complete with the cage and rollers can be pressed either way around onto the crankshaft. The later crankshaft of reduced overall width is identified by the letter 'R' stamped into the timing side crankshaft cheek adjacent to the bearing location. The designed crankshaft fitted end float for the new arrangement is 0.010" to 0.024" (0.254mm – 0.609mm). Alternative bearing types are illustrated below:</p> <div style="text-align: center;"> </div>		Manufacturer	Type	S.K.F.	NJ306 or NJ306E	F.A.G.	NJ306	N.T.N.	NJ306	Hoffman	R306L	R.H.P.	NF306
Manufacturer	Type												
S.K.F.	NJ306 or NJ306E												
F.A.G.	NJ306												
N.T.N.	NJ306												
Hoffman	R306L												
R.H.P.	NF306												
(October 1971)													

⁵ Author's Note: 'LAB' on the Access Norton Forum has pointed out that this is an error. A "1 dot" bearing is the equivalent of a C2, i.e. clearance less than normal, a "2 dot" bearing is normal (CN) clearance and a "3 dot" is equivalent to a C3, i.e. clearance greater than normal. The 'C' internal clearance terminology is defined in DIN 620-4, ISO 5 753 [REF15].

Table 9: Text of Norton Service Release Sheet No N2/6 (July 1972)

Service Release No. N2/6	
Nature of Release	Crankshaft Main Bearings.
Models Affected	1972 models (commencing engine number 200,004)
Distribution	Worldwide
<p>Explanation Field experience with 1972 models (incorporating two single lipped roller main bearings) indicates a small, but significant premature roller main bearing failure rate. Reported failures have been confined solely to one type of bearing.</p> <p>Action:- When replacing defective roller main bearings, ensure the replacement is a Skefco double lipped outer, single lipped inner spool type NJ306, with a specified nominal internal diametral clearance of 0.0008/0.0012ins. (0.02/0.03mm) prior to fitting (ISO Normal). Ensure the crankshaft journals are carefully cleaned up, removing all signs of butts or scoring before fitting the inner spool. Models subsequent to Engine Number 207197 incorporate a nominal increase in bearing housing diameter to overcome any significant tendency to excessive closure of the single lipped outer series of roller bearings.</p> <p style="text-align: right;">(July 1972)</p>	

Table 10: Text of Norton Service Release Sheet No N2/9 (August 1972)

Service Release No. N2/9	
Nature of Release	Crankshaft main (roller) bearings
Models Affected	1972 Commando (all models)
Distribution	Worldwide
<p>Explanation In order to extend main bearing life, a change of roller main bearing specification has now been authorized and fitted on production engines from Engine No. 211891. The new roller bearing is designated 'Superblend' with an increased load carrying capacity and is supplied under Part No. 063906 (manufacturers part number R&M 6/MRJA30).</p> <p>Action:- Where engine units are stripped for examination, or the need for main bearing replacement, fit only roller main bearings Part No. 063906 in place of the previously specified 063114. The new bearings are fully interchangeable, and should be fitted in pairs for maximum reliability.</p> <p>Note:- The new bearings may also be fitted to advantage to 1971 and earlier Commando machines, provided care is taken fitting the inner spool to the right side crankshaft journal (was 1.1807" - 1.1812") diameter, now 1.1812" - 1.1815" diameter. Also crankshaft fitted end float should be checked, and shimmed where necessary to provide 0.010" minimum, 0.020" maximum end float using shim Part No. NMT2196A as necessary.</p> <p style="text-align: right;">(August 1972)</p>	

Table 11: Text of Norton Service Release Sheet No N2/10 (January 1973)

Service Release No. N2/10	
<u>Nature of Release</u>	Extra high capacity main bearings
<u>Models Affected</u>	All Commando
<u>Distribution</u>	Worldwide
<p><u>Explanation</u></p> <p>A new main bearing capable of carrying a much higher load than any offered before, has been introduced.</p> <p>The new bearing, part number 064118, supersedes the old type 063906 and will be supplied in lieu by our Parts Division. The new bearing should be fitted in pairs.</p> <p>This bearing may also be fitted to advantage to engines of 1971 and earlier models (originally fitted with a ball bearing as a timing side main bearing).</p> <p>Ensure that the inner races are firmly seated against the crankcheeks to give a crankshaft end float between 0.010 and 0.024. Any excessive end float can be eliminated by fitting main bearing shims NMT2196A between the outer race and the crankcase.</p> <p style="text-align: right;">(January 1973)</p>	

Table 12: Main bearing part numbers from Norton Parts Lists

Part List Year(s)	Part Number(s)	Description & Notes
1968-70	NM17822 (D) NM17824 (T)	Roller (D=Drive side) Ball (T=Timing side)
1971	NM17822 (D) NM17824 (T)	Roller (D=Drive side) Ball (T=Timing side)
1972	063114	Paired rollers. Introduced in Service Release (SR) No. 68 specifying R&M MRJA30 under part no. 063114. Bearing specification changed in SR N2/6.
None	063906	Changed to R&M 'Superblend' roller bearing in SR N2/9 under part no. 063906. R&M 6/MRJA30 special bearing.
1973	064118	Parts List Publication No. 065034. Part no. 064118 introduced in SR N2/10. Evidence indicates standard FAG NJ306E bearing.
1974	064118	Parts List Publication No. 065988 covering 850 Mk2, Mk2A Standard FAG NJ306E bearing.
1975	064118	Parts list covering 850 Mk3 Standard FAG NJ306E bearing.

Annex 5 – Main bearing types likely to have been failing

The bearing types most likely to have been failing during 1972/3 are those specified in Service Release 68 (October 1971, see page 23) which are also shown in Table 13.

Table 13: Bearing types most likely to be failing with loading values (where known)

Manufacturer	Type	Loading in Newtons (Dynamic/Static)	Notes
R&M (later RHP)	MRJA30	41,900/35,200	Most likely fitted as standard (Part No. 063114). SR 68 is ambiguous in stating 'alternative bearings which may be used' without making it clear whether fitted by the factory from new or as replacements. Equivalent to type NF. N.B. This is MRJA30 without the '6' prefix of the later bearing specified in SR N2/9. Loadings from J.M. Leadbeater [REF1]. <i>See Annex 8, page 30 Illustration 26 and page 31 Illustration 27 for images.</i>
S.K.F.	NJ306 or NJ306E	36,900/20,000 57,200/30,000 ⁶	It is interesting that the 'E' designation bearing is available from SKF but that the bearing recommended in the later SR N2/6 is the SKF NJ306 without the 'E'. It appears that a solution provided by an NJ306E type bearing may have been 'within Norton's grasp' earlier in October 1971 rather than in August 1972 and later. Loadings from J.M. Leadbeater [REF1]. <i>See Annex 8, page 34 Illustration 31 for image of NJ306.</i>
F.A.G.	NJ306	34000/20000	N.B. This is NJ306 without the 'E'. For comparison the NJ306E had loadings of 45400/28500N. Loading values from 1966 FAG catalogue [REF28].
N.T.N.	NJ306	Unknown	No information found but recommending a Japanese manufacturer must have been novel at the time.
Hoffman	R306L	Unknown	Superseded by RHP NF306
R.H.P.	NF306	38200/25100	This is RHP's equivalent to the R&M MRJA30 as specified in the 1972 RHP catalogue on page 231 [REF31]. Loadings are converted from those on page 195 of the catalogue.

⁶ The SKF NJ306E is the least like of those listed above to fail but is included here as it was in Norton's list of bearings in Service Release 68 which were later superseded by those recommended in Service Releases N2/9 and N2/10.

Annex 6 – Changes in roller bearing loadings over time

It is clear from the following graph how the dynamic loading capacities (in Newtons) of roller bearings have increased over time and also the difference between earlier NJ306 and NJ306E bearings:

Illustration 25: Roller bearing dynamic loadings 'then' and 'now'.

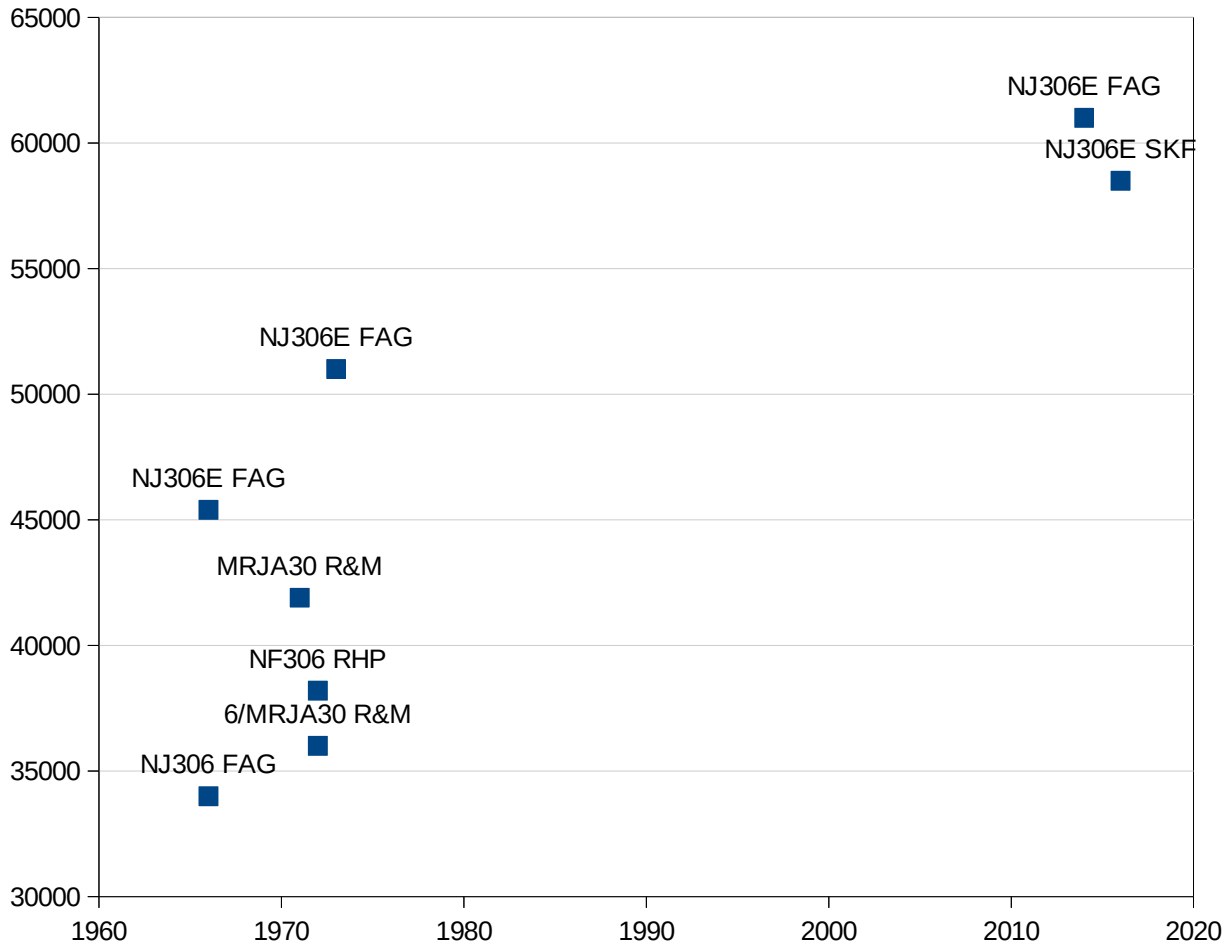


Table 14: Dynamic loadings (in Newtons) by date, bearing designation and manufacturer

Date	Load	Bearing
1966	34000	NJ306 FAG
1966	45400	NJ306E FAG
1971	41900	MRJA30 R&M
1972	38200	NF306 RHP
1972	36000	6/MRJA30 R&M
1973	51000	NJ306E FAG
2016	58500	NJ306E SKF
2014	61000	NJ306E FAG

Annex 7 – Data and information on the TVP2 polyamide roller cages

For the FAG NJ306E bearing the default cage type listed in FAG’s catalogue and offered by general bearing suppliers has the TVP2 type cage. The alternative of the brass cage is the option favoured by the main Commando spares suppliers and owners.

Roller cage types available are shown in FAG’s Catalogue [REF7]. Details are also available in [REF32]. The TVP2 cages are described on page 399 of FAG’s catalogue as being, ‘*Solid window cage made from glass fibre reinforced polyamide PA66*’. Also on page 115, ‘*The elasticity and low mass of polyamide are favourable under shock type bearing loads, high accelerations and decelerations und (sic) tilting of the bearing rings in relation to each other. Polyamide cages have very good sliding and emergency running characteristics.*’

The TVP2 glass-fibre reinforced thermoplastic cage is not favoured because the life of cages made with this material can be reduced by the effects of high temperature and oil additives. However the FAG recommended upper working temperature limit for extended use is 120°C. The oil additives known to cause reduced life are those associated with gear and hypoid oils. Combustion breakdown contaminants in oil have also been mentioned as a potential source of problems but the author has not been able to find any documented evidence for these causing problems with TVP2 roller cage life.

The following engine temperature data are available:

Table 15: Commando Oil Temperature Data

Engine Oil Temperature (°C)	Notes	Source
82-104	Oil temperature operating range	NOC website message posting [REF34].
81	Oil temperature measured after 50 mile run on 1968 Dominator 650SS	NOC website message posting by Charles Hopkinson 2/6/13 [REF34].
88	At oil intake, 65 mph, 32°C air temperature	Goldwater 1993-2000 [REF33]
93	At oil intake, 75 mph, 32°C air temperature	Goldwater [REF33]
100	Maximum temperature with viscosity data point	Morris V-Twin 20/50 4-stroke motorcycle oil datasheet.

All the temperatures shown in Table 15 are well below the upper temperature limit for extended running of 120°C for a roller bearing with the TVP2 roller cage.

A letter in the NOC Roadholder No. 193 [REF35] refers to a reduced availability of brass caged bearings and concerns about the polyamide cages. It also refers to the use of polyamide caged bearings by Steve Maney (see www.stevemaney.com) in race Commando engines.

The follow-up correspondence in Roadholder No. 194 [REF36] includes two positive responses (Andy Dockree & Fred Fagence) concerning TVP and confirmation of the availability of brass caged bearings from Andover Norton (Nick Hopkins).

For information, the upper operating temperature for this roller bearing with a brass cage is 150°C [Page 398, REF7].

Annex 8 – Further images and information for relevant bearings

Illustration 26: R&M MRJA30 removed from a 1969 Commando (Access Norton Forum 'DogT')



By DogT » Sat May 08, 2010 3:52 pm Removed from a 1969 Commando

<https://www.accessnorton.com/NortonCommando/crankcase-superblends-revisited.5648/>

Unfortunately many images are no longer available on Access Norton due to a 'photobucket' change in conditions of use.

This is a standard Ransome & Marles MRJA30 bearing and is probably an original which would have been paired with a ball bearing. The bearing has 13 cylindrical rollers and is type NF. No partial crowning of the rollers is visible.

Illustration 27: RHP MRJA30 'new old stock' Jim Comstock, Access Norton



This is a Ransome, Hoffman & Pollard MRJA30 bearing likely to have been manufactured in the period between 1969 and 1972. The bearing is not listed specifically in the October 1972 RHP catalogue [REF32] although type MRJA is shown cross-referenced to the equivalent RHP series NF300 (page 231 of [REF32]).

Photo from; <https://www.accessnorton.com/NortonCommando/crankcase-superblends-revisited.5648/>

Illustration 28: Roller profile scan for RHP MRJA30 (Jim Comstock)



This shows the standard MRJA30 roller profile which is parallel over nearly all of its length with no partial crowning.

Illustration 29: RHP 8/MRJA30 - an 11 roller variant of the MRJA30 (Images courtesy of TSS Motorcycles of Portland, Oregon)



Illustration 30: Additional Images of RHP 6/MRJA30 showing partial crowning (NOS bearing on loan from Anthony Curzon. Photos by author.)

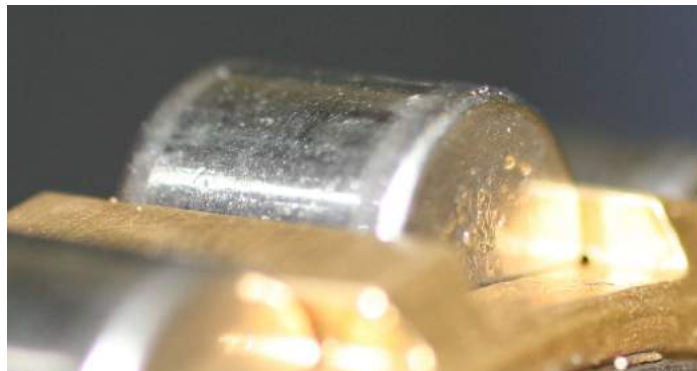


Illustration 31: Image of SKF NJ306 configured bearing. Image courtesy of Brian4.2 (Access Norton).



This bearing was removed from a 1972 Commando with a Combat engine. It has 11 rollers and a steel cage. Like the FAG bearing Jim Comstock removed from a 1974 850 the bearing has an outer ring marked NU with an NJ inner. This results in an NJ configured bearing.

This is the bearing recommended in Service Release N2/6 (July 1972), see Table 9 on page 25, as a replacement for defective bearings. N2/6 was superseded one month later by N2/9 which introduced the 'superblend' R&M/RHP 6/MRJA30.